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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 99.

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THREE INSECT ENEMIES OF SHADE TREES.

BY

L. O. HOWARD,
ENTOMOLOGIST.

[Reprinted, with some annotations by the author, from the Yearbook of the Department of Agriculture for 1895.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., May 26, 1899.

Sir: I have the honor to transmit herewith a copy of an article contributed by me to the Yearbook for 1895, entitled "The shade-tree insect problem in the Eastern United States." I have found the reprints of this article of great use in correspondence, and as the edition is exhausted, I recommend that it be republished, under the title Three Insect Enemies of Shade Trees, as a Farmers' Bulletin. I have in preparation a more extended bulletin on the subject of shade-tree insects, but in the interval which will elapse before it is completed the Farmers' Bulletin reprint of the Yearbook article will be of service.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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THREE INSECT ENEMIES OF SHADE TREES.

The space at command will not admit of a full treatment of the problem outlined in the [original] title of this article, and the writer has therefore brought together at this time some account of three species which are perhaps the most destructive among shade-tree insects, or which, at all events, have attracted the greatest attention during the past season. To this he has added a brief consideration of the relative immunity of shade trees from insect attack, and some remarks on the subject of general work against shade-tree insects in cities and towns.

One of the most striking features of the summer of 1895 has been the great abundance in many Eastern cities of several species of insects which attack shade trees. In almost every low-lying town from Charlotte, N. C., north to Albany, N. Y., the elm leaf-beetle has defoliated the English elms and, in many cases, the American elms. In certain directions this insect has also extended its northern range, notably up the Connecticut River Valley. The authorities in a number of Eastern cities have taken the alarm, and active remedial work will be instituted during the coming season. In cities south of New York the bagworm has been gradually increasing for a number of years until it has become a serious enemy to shade and ornamental trees for almost the first time since 1879 or 1880 (figs. 1 and 2). The white-marked tussock moth, the caterpillar of which has been for many years the most serious of the shade-tree pests in Philadelphia, New York, Brooklyn, and Boston, in 1895, for the first time within the recollection of the writer,

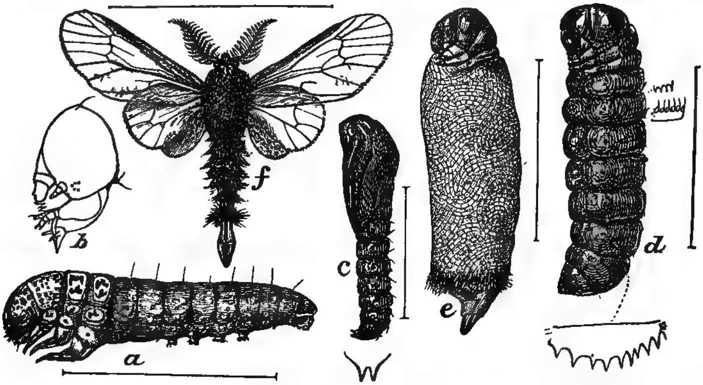

FIG. 1.—Bagworm (*Thyridopteryx ephemeræformis*). *a*, larva; *b*, head of same; *c*, male pupa; *d*, female pupa; *e*, adult female; *f*, adult male—all enlarged (original).

appeared in such numbers as to become of great importance in more southern cities, as Baltimore and Washington. The fall webworm (figs. 9, 10, and 11) was more abundant in Washington and the surrounding country than it has been since the summer of 1886.

These four insects are the principal shade-tree defoliators in the Eastern States, if we except the imported gypsy moth, which is at present fortunately confined to the immediate vicinity of Boston, and is being cared for by a thoroughly capable State commission. While the summer of 1895 may with justice be called an exceptional one as regards the great increase of numbers, yet these insects are always present and do a certain amount of damage each season, and, when an exceptional season comes, as it did in 1895, city authorities seldom find themselves prepared to engage in an intelligent and comprehensive fight.

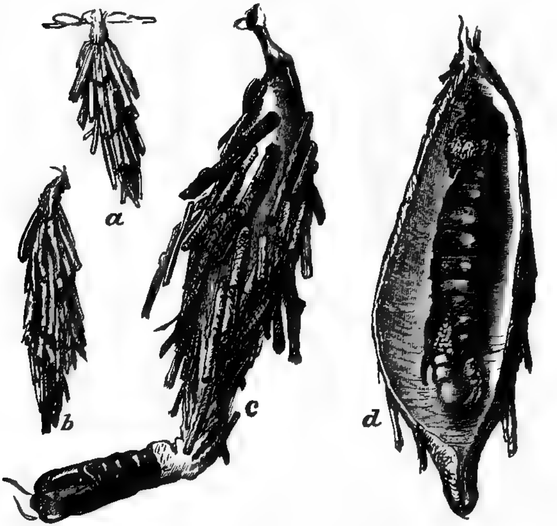

FIG. 2.—Bagworm at (*a*, *b*, *c*) successive stages of growth. *c*, male bag; *d*, female bag—natural size (original).

In cities farther west other leaf-feeders take the place of those just mentioned. The principal ones are, perhaps, the oak Edema, the cottonwood leaf-beetle, and the green-striped maple worm.

Several scale insects or bark lice are occasionally serious enemies to shade trees. Maples suffer especially from their attacks. The cottony maple scale is found everywhere on all varieties of maple, and occasionally in excessive abundance. The cottony maple leaf scale, a species imported from Europe, is rapidly gaining in importance, and in several New England towns it has, during the past season, seriously reduced the vitality of many trees. The so-called "gloomy scale" has long been on the increase in Washington, D. C., and every year it kills large branches and even entire trees of the silver maples, which are so extensively grown along the streets of that city.

Certain borers are also occasionally destructive to many shade trees, and, in fact, in the northern tier of States these are the most important of the shade-tree enemies, the principal leaf feeders being either absent or becoming single brooded. Where absent their places are taken by less destructive species.

In fact, it is safe to say that shade trees suffer especially from insect attack throughout the region of country which is contained in the Upper Austral life zone.[1]

Concerning the borers, it may be briefly said that these insects rarely attack vigorous and healthy trees, but should a shade tree lose its health through the attacks of scale insects, through rapid defoliation by leaf feeders, or through a leaky gas main or sewer pipe, different species of borers will at once attack and destroy it. There is one particular exception to this rule, and that is the European leopard moth, a most destructive species, which is at present of very limited range and confined to the immediate vicinity of New York City. No certain information is at hand which indicates that it has spread for more than 50 miles from the center of introduction. This insect attacks healthy trees, boring into the trunks of the younger ones and into the branches and smaller limbs of many shade and fruit trees. It is an extremely difficult species to fight, and it is fortunate that its spread is not more rapid.

THE IMPORTED ELM LEAF-BEETLE.

(*Galerucella luteola* Müll.)

Original home and present distribution.—The imported elm leaf-beetle (fig. 3) is a native of southern Europe and the Mediterranean islands. It is abundant and destructive in the southern parts of France and Germany, and in Italy and Austria. This beetle is found, though rarely, in England, Sweden, and north Germany, and gradually becomes less numerous and destructive toward the north. In middle Germany it is common, though not especially destructive. As early as 1837 it was imported into the United States at Baltimore, and is now found as far south as Charlotte, N. C. From this point it ranges northward in the Atlantic cities as far as Providence, R. I. Inland it has not passed the barrier of the Appalachian chain of mountains, and is practically confined to the Upper Austral region, as indicated in the map on page 210 of the Yearbook for 1894. Thus, up the Hudson River it has spread to Albany, N. Y., but on either side of the river, as the land rises into the foothills, it has stopped. In the same way it has more recently spread up the Connecticut River Valley to a point north of the New Hampshire State line, and also, to a less extent, up the Housatonic Valley. From our present knowledge it seems likely that its future spread as an especially destructive species will be limited by the northern border of the Upper Austral region, and that (as may happen at any time) should it once be carried by railway train across the southern extension of the Transition life zone, caused by the Alleghany and Blue Ridge mountains, it will spread unchecked through Ohio, Indiana, Kentucky, Tennessee, and other Western States.[1]

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[1] Briefly defined by Dr. Merriam in his summary article on "The geographic distribution of animals and plants in North America," in the Yearbook of this Department for 1894, page 203.

Food plants.—No food plants other than elms are known. The common English elm (*Ulmus campestris*) is its favorite food, and the gardener's variety, the so-called Camperdown, or weeping elm, is attacked with equal avidity. The American, or white, elm (*U. americana*) ranks next among the favored species, with *U. montana*, *U. suberosa*, *U. flava*, *U. racemosa*, and *U. alata* in about the order named. No variety seems absolutely exempt. In the presence of *U. campestris* other elms are seldom seriously injured. Where *campestris* is absent, or where a single tree of *campestris* is surrounded by many American elms, the latter become seriously attacked.[2]

Life history and habits.—The elm leaf-beetle passes the winter in the adult, or beetle, condition in cracks in fences or telegraph poles, under the loose bark of trees, inside window blinds in unoccupied houses, in barns, and, in fact, wherever it can secure shelter. As soon as the buds of the trees begin to swell in the spring, the beetles issue from their winter quarters and mate, and as soon as the buds burst they begin to feed upon the leaflets.

This feeding is continued by the beetles until the leaves are fairly well grown, and during the latter part of this feeding period the females are engaged in laying their eggs. The eggs (fig. 3, *c*) are placed on the lower sides of the leaves, in vertical clusters of 5 to 20 or more, arranged in two or three irregular rows. They are elongate oval in shape, tapering to a rather obtuse point, orange yellow in color, and the surface is covered with beautiful hexagonal reticulations. These reticulations, however, can be seen only with a high magnifying power.

The egg state lasts about a week. The larvæ (fig. 3, *d*) as soon as hatched feed on the under surface of the leaf, gradually skeletonizing it. They reach full growth in from fifteen to twenty days, and then either crawl down the trunk of the tree to the surface of the ground or drop from the extremities of overhanging branches. At the surface of the ground they transform to naked, light orange-colored pupæ (fig. 3, *g*) a little over a quarter of an inch in length, and in this stage they remain for from six to ten days, at the expiration of that time transforming to beetles. The pupæ will frequently be found collected in masses at the surface of the ground in this way. On very large trees with shaggy bark many larvæ will transform to pupæ under the bark scales, or on trees of the largest size they may descend the main

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[1] Since this was written the writer has learned that this passage of the Blue Ridge barrier has actually taken place during the past season. Mr. A. D. Hopkins, of the West Virginia Agricultural Experiment Station, has found that this insect has established itself at Elmgrove, in Ohio County, and at Wellsburg, in Brooke County, W. Va.

[2] The beetles rarely oviposit upon *Zelcova carpiniafolia* and *Z. acuminata* on the Department grounds at Washington.

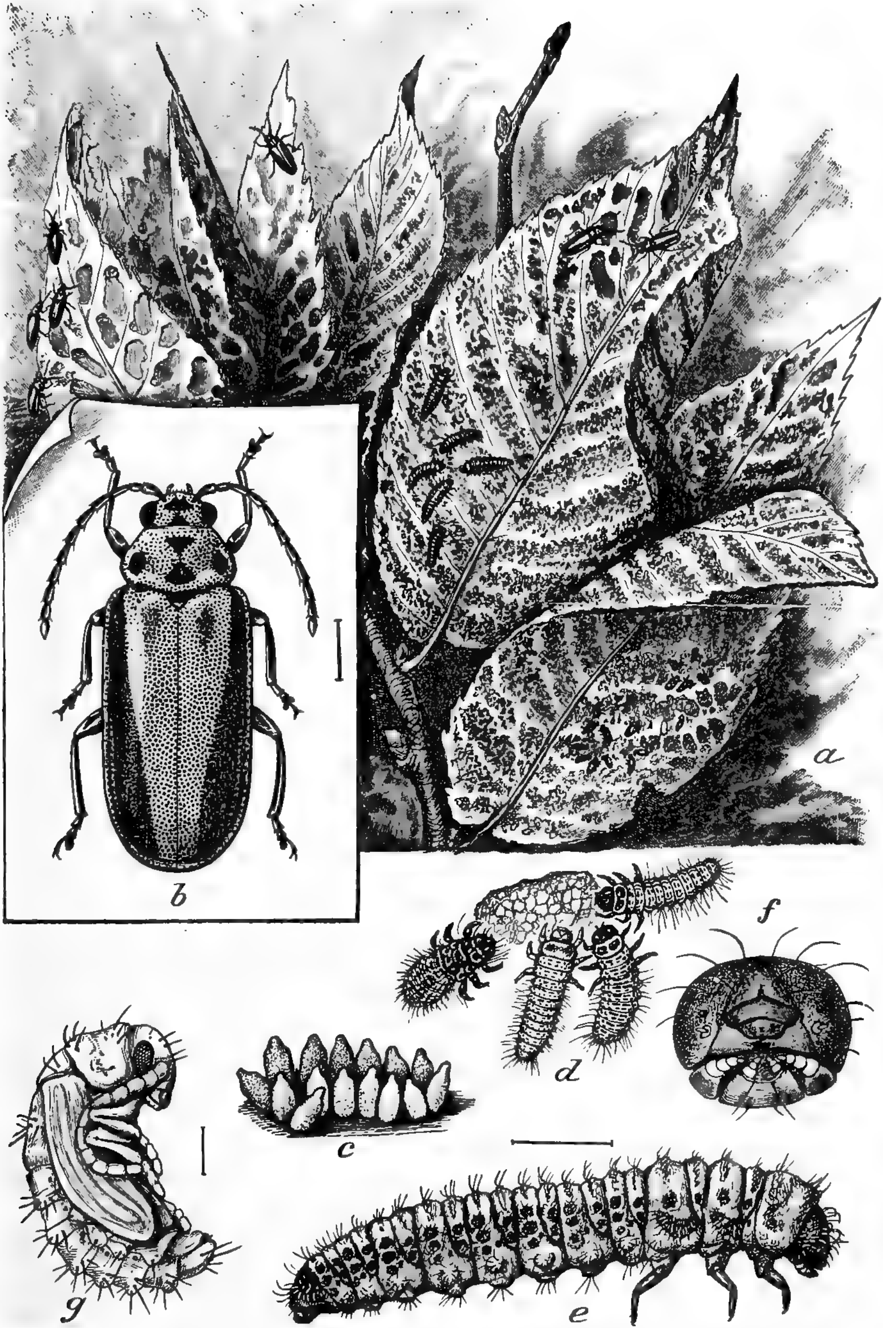

FIG. 3.—The imported elm leaf-beetle (*Galerucella luteola*). *a*, foliage of European elm showing method of work of beetle and larva—natural size; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *e*, full-grown larva; *g*, pupa—all greatly enlarged; *f*, mouth parts of full-grown larva—still more enlarged (original).

branches to the crotch and transform unprotected in the hollow of the crotch.

The larva is elongate, reaching when full grown (fig. 3, *e*) half an inch in length. When first hatched it is nearly black; as it increases in size it becomes, with each shedding of the skin, more distinctly marked with yellow, and when mature the yellow predominates, occurring as a broad dorsal stripe and two lateral stripes.

The difference between the early work of the beetles and the later work of the larvæ is recognized at a glance. The beetles eat entirely through the leaves and make complete, irregular holes, while the larvæ simply eat the parenchyma from below, skeletonizing the leaf.

The time occupied in egg laying is long, and it thus happens that at the time when full-grown larvæ, and even pupæ, are to be found there are also upon the leaves freshly laid eggs.

In Washington there are invariably two generations annually, the beetles developed from the eggs laid by the overwintered beetles themselves laying their eggs in July. The adults issuing from these eggs make their appearance in August. Farther north, at New Brunswick, N. J., and in the Connecticut cities, it may be said that there is normally a complete first generation and an incomplete second generation.

The proper food of the larvæ is the rather young and tender leaves. If the work of the first generation has not been complete, and the trees have not been so nearly defoliated as to necessitate the sending out of fresh leaves, or if a period of drought ensues after defoliation and prevents the putting out of a second crop of leaves, the beetles of the first generation do not lay eggs, but after flying about for a time seek winter quarters. This may occur as early as the middle of July. Where, however, defoliation has been complete and has been followed by a period of sufficient moisture to enable a tree to put out a fresh crop of leaves, the beetles of the first generation will lay their eggs and a second generation of larvæ will develop upon this comparatively tender foliage. Where similar conditions prevail in Washington and its vicinity, a third generation of larvæ may develop, though small in numbers, but the writer is convinced that even in Washington late-developing beetles of the first generation may hibernate.

Remedies.—The only thoroughly satisfactory safeguard against this insect consists in spraying the trees with an arsenical solution. The only other remedy which is worthy of mention is the destruction of the larvæ at the surface of the ground before or after they transform to pupæ. The latter remedy, however, is not complete, and even where it is carefully carried out for every tree in a city it will do no more than reduce the numbers of the insects by perhaps two-thirds.

Ten years ago a proposal to spray the enormous elms which are to be found in many Northern towns would have been received with ridicule, but of recent years the practicability of the plan has so frequently been demonstrated that there is no hesitancy in commending it to more general city use. Probably the largest elm tree in America, the Dexter elm at Medford, Mass., has been successfully and economically sprayed by the Gypsy Moth Commission. It is necessary to have especial apparatus constructed, and it is equally necessary to have the work done by men who are accustomed to it or at least are good climbers. The first successful work of this kind was probably that done by Prof. John B. Smith, on the campus of Rutgers College. He had a strong barrel pump, and carried the nozzle at the end of a long rubber tube, with a bamboo extension pole, up into the center of the trees by climbing a ladder to the main crotch. From this point the spray was thrown in all directions, and the tree was thoroughly coated with the mixture in a minimum of time.

The Gypsy Moth Commission, in their earlier spraying work, sent their large tank carts through the streets, stopping at each tree and sending one or more men with hose and extension poles into it, thus covering hundreds of large trees in a single day. If steam sprayers are used (and the town or city fire engines can be and have been used to excellent advantage in this way), the necessity for climbing the trees may be largely avoided. By means of multiple-discharge hose both sides of a tree, or even of two trees, may be sprayed at once, and the extent of territory that may be covered in a day is surprising. The elm trees in a small park may be treated economically and without much difficulty by two or three men with a handcart tank. This method has been adopted on the large grounds of the Department of Agriculture with absolute success.

The writer's experience at Washington leads to the conclusion that it is important to spray trees once just after the buds have burst. This spraying is directed against the overwintered beetles. If a large proportion of these beetles can be destroyed by poisoning the leaves which they eat, not only will a great deal of leaf perforation by the beetles themselves be prevented, but the number of eggs laid will be very greatly lessened. A second spraying should be conducted two weeks later. This is directed against the larvæ, the majority of which will perhaps have hatched by that time or soon after. A third spraying, and even a fourth, or under exceptional circumstances a fifth, may be required if it is considered necessary to keep the trees fresh and green, and particularly if the earlier sprayings have been followed by rains, as is apt to be the case in the earlier part of the season. In Bridgeport, Conn., where only a part of the trees are sprayed and these by private enterprise, an even greater number of operations have been found desirable. Three thorough sprayings of all the trees in a given precinct will probably be as much as will be required, especially if this be done year after year and some pains be taken to destroy such of the larvæ as may successfully develop and descend for transformation. Even two sprayings, covering all the elms of a city or town, will be well worth the expense.

The substance to be used in these spraying operations may be Paris green, London purple, or arsenate of lead. The directions for the use of these substances have been so often repeated, that it is not worth while to mention them here.

The other remedy—the destruction of the descending larvæ and the quiescent pupæ—is, as above stated, and must always be, incomplete. The standard kerosene emulsion, diluted one part to five parts of water, will destroy the insects in either of these stages. This has been successfully used in several New England towns the past season, particularly in New Haven. It must be applied to the base of the trunk and under the entire limb spread of the tree. The rough bark must be removed to a slight extent (the writer does not advocate severe scraping), leaving as few crevices as possible which may harbor the pupating insects. If a tree is very large, it will pay occasionally to climb into the main crotch and destroy such individuals as may have collected at that point. Experience leads us to the estimate that on large trees not more than one-half to two-thirds of the larvæ reach the base of the trunk and transform at that point. The extent to which larvæ drop from overhanging branches has been questioned, and it is sometimes a difficult matter to decide. The city forester of Springfield, Mass., however, called our attention to a peculiar and eminently satisfactory case where the drooping branches of a large elm extended completely over a house on the other side of which there were no elm trees. On the far side of the house, beneath the tips of the overhanging branches, the larvæ and pupæ were collected in large numbers in the summer of 1895.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* Smith and Abbot.)

Original home and present distribution.—This insect is a native of North America. It ranges from Jacksonville, Fla., to Nova Scotia, on the eastern coast, and extends west certainly as far as Keokuk, Iowa, and probably farther, although the records at command include no actual captures beyond this point.[1] It does not occur in California, so far as learned.

Food plants.—It attacks almost every variety of shade, fruit, and ornamental trees, with the exception of the conifers. In the city of Washington it seems to select by preference the poplars, soft maples, the elms, alders, and birches, as well as the willows. It is also found here on apple, pear, cherry, plum, peach, other varieties of maple, locust, box elder, ash, catalpa, rose, horse-chestnut, persimmon, sycamore, mulberry, and a number of other trees.

Life history and habits.—This insect passes the winter in the egg state. The overwintering eggs are laid by the female moth in the latter part of September, in a glistening white, frothy-looking mass attached to the outside of the cocoon. They are seen at a glance, owing to their pure white color, and remain conspicuous upon the trees until spring. The caterpillars hatch in Washington in April and May. They are represented at different stages of growth in figs. 4, 5, and 6, and in view of the care with which these figures have been drawn detailed descriptions will be unnecessary. They cast the skin five times, exhibiting a different character after each molt, as indicated in the figures. The newly hatched young feed on the under surface of the leaf, eating off the parenchyma and producing a skeletonized appearance. After the first molt the skeletonizing continues, but a few holes are eaten completely through the leaf; after the second molt many holes are eaten through between the main ribs, and after the third molt the leaf is devoured, except for the midrib and its principal branches. After the fourth molt the caterpillars begin to eat from the edge of the leaf and devour everything except the principal veins.

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[1] Prof. L. Bruner has since reported this species from Omaha and Lincoln, Nebr.

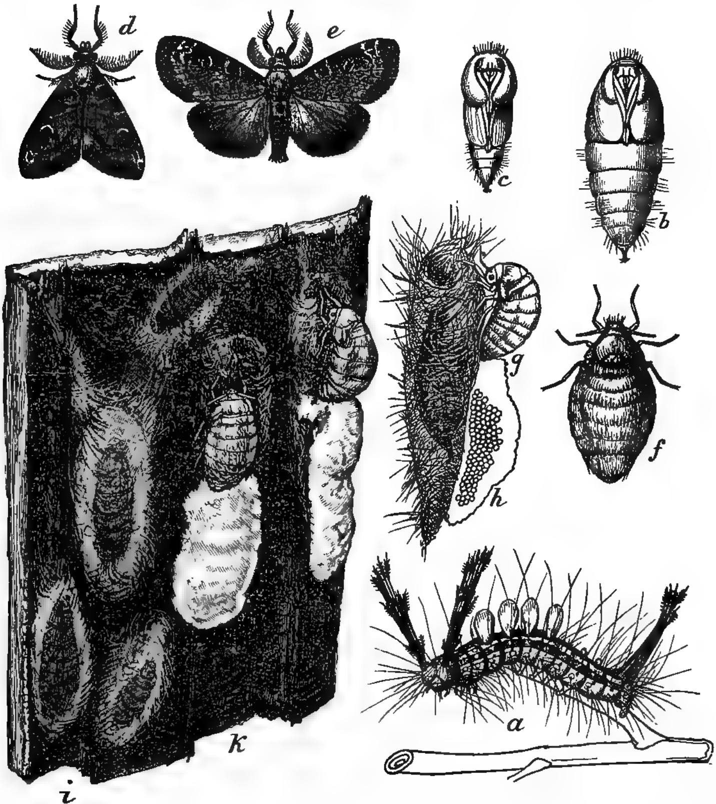

Fig. 4.—*Orgyia leucostigma.* *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs—all slightly enlarged (original).

Similar work is done in the last stage upon the full-grown and tough leaves (see fig. 7).

A most peculiar kind of damage by the caterpillars of this species has been observed by Dr. Lintner in Albany, N. Y. There, in the summer of 1883, he found that the tips of many twigs were girdled by the caterpillars, which had entirely removed the bark for a tenth of an inch. Such twigs broke off and fell to the ground, with their leaves. This damage was so common in 1883 that the sidewalks of the streets and public parks wherever the American elm was growing were sprinkled with the newly fallen leaves. Dr. Lintner was of the opinion that a cold spring and the sudden advent of warm weather caused an unusually vigorous growth of the terminal twigs, and that the young tips were therefore unusually tender. They thus proved appetizing to the tussock-moth caterpillars, which developed a new habit for the occasion. This peculiar damage was repeated in 1895, but to a less extent. No other observer in any part of the country has ever reported similar damage.

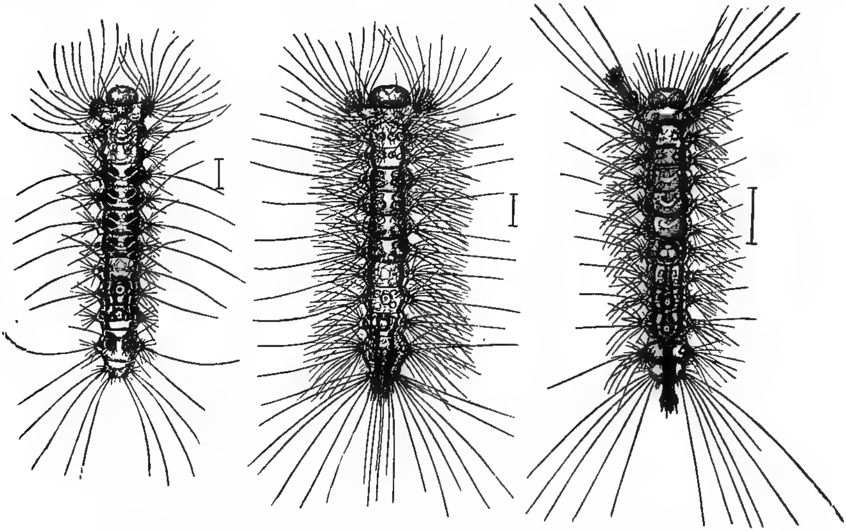
FIG. 5.—Tussock-moth caterpillar. First, second, and third stages—enlarged (original).

The young caterpillars drop down, suspended by silken threads, at even a slight jarring of the tree, and frequently spin down without such disturbance, and are blown to a considerable distance by the wind. When nearly full grown they are great travelers, crawling down the trunk of the tree upon which they were hatched and across a considerable stretch of ground, to ascend another tree. When they occur in numbers, an extensive migration will always take place from a tree which has been nearly defoliated, and the species spreads mainly, if not entirely, in this way. Just as is the case with the gypsy moth, the caterpillars are carried by vehicles upon which they crawl or drop, or upon the clothes of passers-by, and in this way many trees upon which there were no egg masses become infested.

The larval state lasts, on an average, from a month to five weeks. When full grown, the larvæ spin delicate grayish cocoons of silk mixed plentifully with hairs. The mixture of hair is brought about by the fact that the hairs are barbed and rather loosley attached to the body. When a caterpillar begins to spin its cocoon the hairs of its body and those of the long, black tufts on the prothorax first become entangled with the silken threads and are pulled out. By the time the cocoon has begun to take shape, the characteristic long, black tufts of hair have entirely disappeared from the body of the caterpillar. Later the shorter hairs of the sides of the body become entangled and removed, and finally many of the hairs composing the brush-like tufts upon the fore part of the body are pulled out, and just before it transforms to pupa the caterpillar bears but a remote resemblance to the individual before it began to spin.

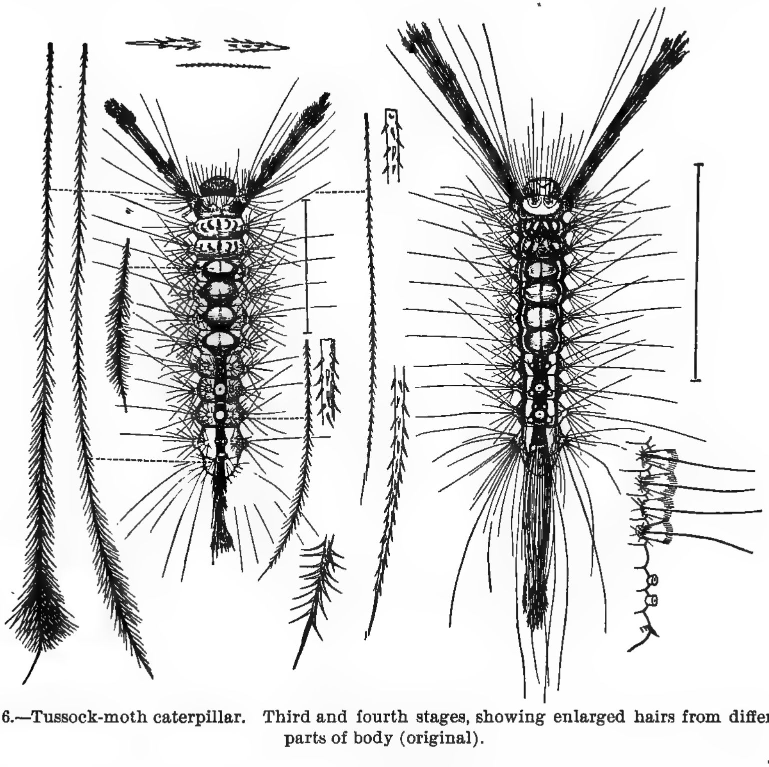

FIG. 6.—Tussock-moth caterpillar. Third and fourth stages, showing enlarged hairs from different parts of body (original).

The barbed hairs just mentioned may occasionally produce considerable irritation of the skin of people upon whom the caterpillars may have crawled or dropped from the trees. The hairs from the different portions of the body of the full-grown caterpillar are illustrated, greatly enlarged, in fig. 6, and it is the shorter hairs from the sides which probably cause the irritation. They are very small, fall out readily, and, when a caterpillar crawls over the skin of an individual who is warm and perspiring, these very sharply barbed hairs produce an irritation which in some individuals has been the cause of much discomfort, creating more or less inflammation and swelling.

The larva transforms to pupa within a few hours after the completion of the cocoon, and remains in the pupal condition from ten days to two weeks. The cocoons of this first generation, while mainly spun on the trunk and larger branches, are also spun to a very considerable extent upon the smaller branches and twigs, and even on the partly eaten leaves.

The adult insect presents the rather unusual phenomenon of a winged, active male and a degraded, absolutely wingless female. It is this fact which makes the spread of the species dependent upon the traveling powers of the caterpillar, as mentioned in the preceding paragraph. The male and female pupæ and the male and female moths are so well shown in fig. 4 as to need no description.

Coupling takes place upon issuing from the cocoon, and immediately afterwards the females begin to lay their eggs, clinging firmly to the cocoons from which they have issued and attaching the egg mass to the lower half of the cocoon, in the manner shown in fig. 4, *h* and *k*. As soon as the eggs are laid the females die, and usually fall to the ground, although sometimes their shriveled bodies remain clinging by the legs to the upper part of the cocoon.

We have made no observations as to the duration of these midsummer eggs. Unfortunately, upon the length of time which elapses before hatching depends exact information as to the number of annual generations. Specific observations in 1895 in Washington were not begun until August 15. At that time the egg masses were everywhere to be seen, and about that time the eggs began to hatch. From the early statements of Riley it was assumed that these were the eggs of the second generation, but reference to the notebooks of the office shows that on several occasions overwintered eggs have hatched in Washington in April, and adults have issued as early as the middle of June. From the middle of June to the middle of August is certainly long enough to allow for a generation of this insect. Assuming that such a generation had developed, larvæ from these August eggs would belong to the third generation.[1] This, however, is to a certain extent guesswork, and the regrettable lapse of observations during the last half of

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[1] Observations made during 1896 confirmed fully the surmise here recorded that the white-marked tussock moth has at Washington three generations annually, instead of two, as previously stated by Riley. (See Bulletin 10, Division of Entomology, p. 33.)

June, the whole of July, and the first half of August could be remedied only in another season.

Elaborate observations were made upon this August brood in 1895, the individuals of which were present in extraordinary numbers. Certain of the larvæ under observation, which hatched on August 2, commenced to spin upon September 3, and on September 14 the first male moths made their appearance, the first females issuing September 19. During the latter part of September the bulk of the moths issued, and the conspicuous white egg masses were very abundant by the 1st of October. Many of these egg masses were kept under observation from that time on. In the cold room of the insectary (temperature the same as outdoors) a few eggs hatched about the close of the second week in October, and on October 23 two newly hatched larvæ were observed upon an egg mass collected out of doors. This late fall hatching, however, is probably exceptional, but in a late, warm autumn it is likely to be rather general. It is hardly to be supposed that any individuals hatching after the 1st of October will successfully transform. The cocoons of this late fall generation are almost invariably spun upon the trunk of the tree and in the crotches of the main limbs, but occasionally, in the case of large trees, upon the larger limbs themselves. The tendency of all the larvæ of this generation is to crawl toward the ground before transforming. Cocoons are occasionally spun upon fences or other objects near the trees upon which the larvæ have been reared, but the vast majority are found upon the trunks.

There are, then, certainly two, and probably three, annual generations at Washington.[1] In New York and Brooklyn there are two well-marked generations. At Boston, as is learned from Mr. Samuel Henshaw, there are two generations. Farther north, however, although the statement is based upon no exact observation, it is not at all likely that there are more than one, and, as stated in the introduction, the comparative harmlessness of the species in such regions is probably due to the nondevelopment of the second generation.

Remedies.—There are two classes of remedies as well as an excellent preventive that may be used to advantage against this insect. These are the collection or destruction of the eggs in the winter, spraying the trees against the larvæ, and banding unattacked trees to prevent the ascent of the caterpillars and the subsequent development of moths and the laying of eggs.

The collection and destruction, or the destruction without collecting, of the eggs must be thorough in order to have any practical efficacy. The great majority of the hibernating egg masses are deposited low down on the trunk of the tree or upon the main limbs, so that they can be reached in one way or another without much difficulty. The egg mass is compact, and, being attached to the somewhat flimsy cocoon and not to the bark, it is easily removed either by hand or by scraping it off. The egg masses which have been scraped off must not be allowed to remain at the surface of the ground, but should be collected and burned. A scraper for the removal of egg masses which occur too high to be reached by hand has been devised by Mr. Southwick, of Central Park, New York City, and consists of a very small hoe blade at the end of a long pole. Perfectly unskilled labor can be utilized in this operation, but the workman should be impressed with the necessity of absolute thoroughness; not an egg mass should be overlooked.

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[1] Certainly occasionally, and probably always, three, as indicated in the footnote on the preceding page.

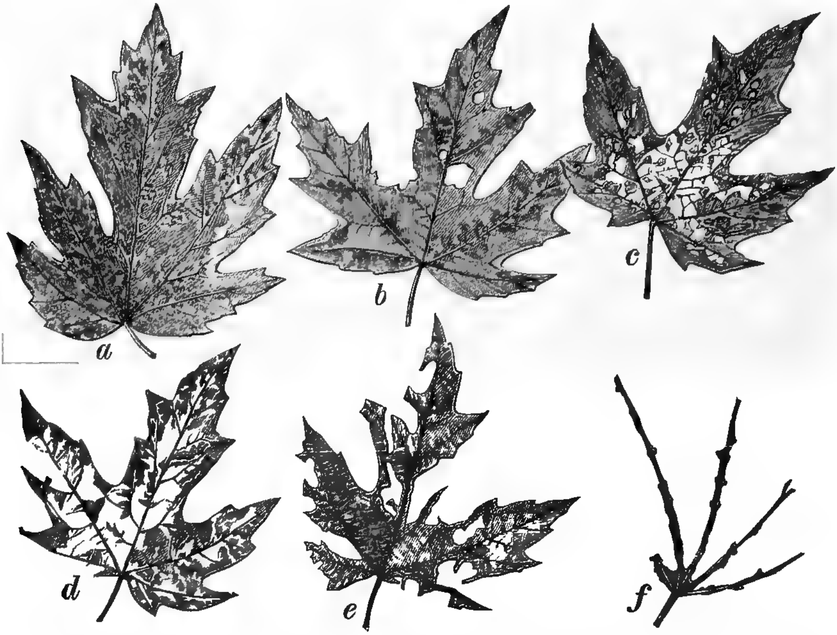

FIG. 7.—Silver maple leaves eaten by larvæ of white-marked tussock moth in successive stages of growth, from *a* (newly hatched larvæ) to *f* (full-grown larvæ)—reduced (original).

In the work against the gypsy moth in Massachusetts it has been found that the egg masses can not be removed to the best advantage by means of scrapers. The eggs are attached, not to the cocoons, but to the bark of the trees, and certain eggs may be left in the attempt to remove the mass. An extensive series of experiments has therefore been carried on with a view to securing a liquid which will penetrate and destroy the egg masses.

A satisfactory liquid for this purpose has been found in creosote oil, to which turpentine is added to keep it liquid in cold weather, with tar to blacken it so that treated egg masses can be recognized at a glance.

The workman is furnished with a pole, to the end of which a small sponge is tied. He goes from tree to tree, dipping the sponge occasionally into the creosote preparation and touching with it each egg mass found. This is a simple and very rapid method. It has the advantage of rapidity over the scraping method described above, since after the eggs are scraped off they must be collected and carried away for burning.

A modification of this plan may be used to advantage against the tussock moth. The pure white color of the egg mass of the tussock moth, however, renders the use of coal tar in the preparation unnecessary, since the creosote oil alone will discolor it enough to render a treated mass recognizable at a distance.

No explicit directions for spraying with arsenical poisons against this insect are needed. The same liquid and the same apparatus that are used against the elm leaf-beetle may be used against this insect, and the spraying may be done at about the same time of the year. It is essential that the caterpillars of the first generation shall be killed, as the second and more destructive brood will thus be prevented.

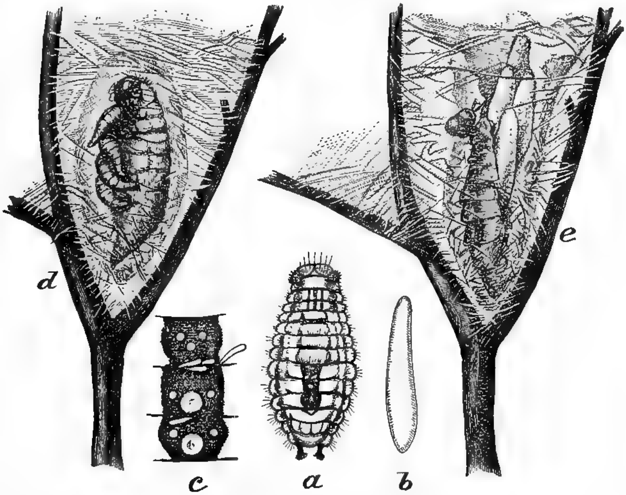

FIG. 8.—*Pimpla inquisitor*, an Ichneumonid parasite of tussock-moth caterpillar. *a*, parasitized caterpillar; *b*, egg of parasite; *c*, same *in situ*; *d*, parasite larvæ issuing; *e*, parasite cocoons—all slightly enlarged, except *b* and *c*, which are much enlarged (original).[1]

Banding of the trees is practiced to advantage with this species. It is the only one of the shade-tree insects, except the bagworm, which has a wingless female. All the others, except the gypsy moth, spread from tree to tree by the flight of the female. Many experiments have been made with different styles of bands, and it has been practically proved that a broad, thick strip of raw cotton, tied about the trunk of the tree with a string, is after all the most efficacious and perhaps the cheapest. Such bands have to be renewed occasionally, as they become more or less matted together and spoiled by rainstorms.

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[1] See Bulletin 5, technical series, Division of Entomology, and Bulletin 9, new series, pages 15–17, for an extended account of the parasites of this species. The injurious outbreak of 1895 was checked in the most perfect manner by these parasites, so that the tussock moth was hardly to be noticed during the latter part of 1896, or during 1897 or 1898.

Next in point of efficacy will probably come bands of insect lime, several brands of which are on the market. Insect lime is a sticky, coal-tar product, which retains its viscidity for a considerable time. A ring made around a tree will remain operative for some weeks in warm weather.

THE FALL WEBWORM.

(*Hyphantria cunea* Drury; figs. 9 to 11.)

Associated with the white-marked tussock moth in its damage to the shade trees of the city of Washington during the summer of 1895, were very many specimens of the fall webworm; in fact, this insect was more abundant during the summer of 1895 than it has been in Washinton since 1886. It was not as numerous and destructive as the white-marked tussock moth, and the last generation was so extensively parasitized as to lead to the anticipation that the species would not be especially abundant during 1896.

The fall webworm is a typical American species. It is found from Canada to Georgia and from Montana to Texas, It is an almost universal feeder, and the records of the Division of Entomology list about 120 species of shade and ornamental trees, as well as fruit trees, upon the leaves of which it feeds.

In the District of Columbia and north to New York City there are two generations annually, as is the case with the tussock moth. In more northern localities, where it is single-brooded, it loses its place as a species of great importance. It hibernates as a pupa within a cocoon attached to the trunk of its food plant, or to tree boxes, neighboring fences, or to rubbish and sticks or stones at the surface of the ground. The different stages of the insect are shown in figs. 9 to 11. The moth, which may be either pure white or white spotted with black, flies at night and deposits a cluster of 400 or 500 eggs, upon either the upper or the under surface of the leaf. The caterpillars feed gregariously, and each colony spins a web which may eventually include all the leaves of a good-sized limb. Reaching full growth, the caterpillars leave the web and crawl down the trunk of the tree to spin their cocoons. The caterpillars of the second generation begin to make their appearance in force in August.

Remedies.—On account of the fact that the adult female is an active flier, we can use against the fall webworm but two of the remedies suggested for use against the tussock-moth caterpillars, namely, spraying with arsensical poisons and the collection of the cocoons. The gregarious habit of the larvæ, however, suggests another remedy which is practical and very efficient if thoroughly carried out. This is the destruction of the webs and the contained larvæ, either by cutting off the twigs which carry them and burning immediately, or burning the webs without pruning. If this work be done properly and against the early summer generation, the pruning method is unnecessary and inadvisable. By the use of a proper torch the webs and the caterpillars which they contain can be burned off at nightfall without necessarily destroying the life of the twigs, and a second crop of leaves will be put out a little later, so that the tree does not remain disfigured for any length of time. A bundle of rags wired to the end of a pole and saturated with kerosene makes a good torch for the purpose; or a porous brick wired to a pole and saturated with kerosene answers the purpose even better. Private persons will find this remedy sufficient. City authorities should apply an arsenical spray. Collecting the cocoons in winter may be carried on simultaneously with the collection of the egg masses of the white-marked tussock moth, but this, as well as other community remedies, will be referred to at another place.

THE RELATIVE IMMUNITY FROM INSECTS OF DIFFERENT VARIETIES OF SHADE TREES.

As regards a number of the principal shade trees that are most commonly grown, there does not seem to be any great preference on the part of the fall webworm and the tussock-moth caterpillar. If a moth happens to lay her eggs upon or near a given tree standing in a row, the species will naturally spread along the row before it will cross to the opposite side. In this way erroneous ideas of the relative immunity of trees have frequently been gathered.

Taking the insect question as a whole, however, there is a decided difference in the relative value of certain varieties. In December, 1893, the Tree Planting and Fountain Society of Brooklyn asked a number of experts to name for the use of the society nine of the most valuable trees for planting in Brooklyn. Three of these trees were to be large-growing, three medium-sized, and three small-growing varieties.

The reply of Mr. B. E. Fernow, Chief of the Division of Forestry in the United States Department of Agriculture, was comprehensive and of great value. He tabulated nearly 50 varieties, analyzing their good qualities under the different heads of endurance, recuperative power, cleanliness, beauty of form, shade, leaf period, rapidity of growth, and persistence, giving 3 as the highest mark for any one of these qualities and estimating the value of a given tree by the total number of marks given to it. This reply was printed and issued as a circular by the Brooklyn society. Mr. Fernow made no specific rating for immunity from insect pests, although in his introductory remarks he seems to have included the insect question under the head of cleanliness.

As is quite to be expected, the rating arrived at from the summing up of the qualities mentioned differs very considerably from the rating which might be arrived at from the quality of immunity from insects. Taking the large and medium-sized trees only (36 species in all), Mr. Fernow's rating stands as follows, only the total gained by the addition of the ratings in the several qualities considered being given:

Variety of tree.	Total rating (Fernow).	Insect rating (Howard).
LARGE-SIZED TREES.		
Red oak (*Quercus rubra*)	22	2.5
Scarlet oak (*Quercus coccinea*)	22	2.5
Yellow oak (*Quercus velutina*)	22	2.5
American elm (*Ulmus americana*)	22	1.5
Sugar maple (*Acer saccharum*)	19	2.5
Black maple (*Acer nigrum*)	19	2.5
Tulip tree (*Liriodendron tulipifera*)	19	3.0
European linden (*Tilia vulgaris*)	19	1.5
Small-leafed linden (*Tilia microphylla*)	19	2.0
Sweet gum (*Liquidambar styraciflua*)	19	2.0
White oak (*Quercus alba*)	19	2.0
Bur oak (*Quercus macrocarpa*)	19	2.0
Oriental plane tree (*Platanus orientalis*)	19	1.5
Kentucky coffee tree (*Gymnocladus divisus*)	19	2.0
American plane tree (*Platanus occidentalis*)	18	1.5
Sycamore maple (*Acer pseudo-platanus*)	17	2.0
American linden (*Tilia americana*)	17	1.5
MEDIUM-SIZED TREES.		
Red maple (*Acer rubrum*)	22	2.0
Shingle oak (*Quercus imbricaria*)	21	2.0
Willow oak (*Quercus phellos*)	21	2.5
Slippery elm (*Ulmus pubescens*)	21	2.0
Norway maple (*Acer platanoides*)	20	2.0
Box elder (*Negundo negundo*)	20	.0
European elm (*Ulmus campestris*)	19	.5
Scotch elm (*Ulmus montana*)	19	1.0
Hackberry (*Celtis occidentalis*)	19	1.5
Silver-leafed maple (*Acer saccharinum*)	17	1.5
Tree of heaven (*Ailanthus glandulosa*)	16	2.5
Horse-chestnut (*Æsculus hippocastanum*)	16	2.0
Japanese sophora (*Sophora japonica*)	16	2.5
Hardy catalpa (*Catalpa speciosa*)	16	2.0
Gingko (*Gingko biloba*)	16	3.0
Honey locust (*Gleditschia triacanthos*)	15	1.0
Cottonwood (*Populus monilifera*)	15	.5
Balm of Gilead (*Populus balsamifera* v. *candicans*)	15	.5
Black locust (*Robinia pseudacacia*)	14	.5

The writer has made ratings of these same trees according to their immunity from the attacks of insects, the trees most immune being rated at 3 and those most attacked by insects at 0. The figures relating to insect attack are displayed above in a contrasted column next to the total rating, and in order that the relative importance from the insect standpoint may be seen at a glance the same trees have been rearranged in a separate table as follows:

Variety of tree.	Insect rating.	Variety of tree.	Insect rating.
Gingko (*Gingko biloba*)	3.0	Shingle oak (*Quercus imbricaria*)	2.0
Tulip tree (*Liriodendron tulipifera*)	3.0	Slippery elm (*Ulmus pubescens*)	2.0
Sugar maple (*Acer saccharum*)	2.5	Norway maple (*Acer platanoides*)	2.0
[1] Red oak (*Quercus rubra*)	2.5	Hardy catalpa (*Catalpa speciosa*)	2.0
Tree of heaven (*Ailanthus glandulosa*)	2.5	European linden (*Tilia vulgaris*)	1.5
[1] Scarlet oak (*Quercus coccinea*)	2.5	American elm (*Ulmus americana*)	1.5
Yellow oak (*Quercus velutina*)	2.5	Hackberry (*Celtis occidentalis*)	1.5
Willow oak (*Quercus phellos*)	2.5	Silver-leafed maple (*Acer saccharinum*)	1.5
Black maple (*Acer nigrum*)	2.5	Oriental plane tree (*Platanus orientalis*)	1.5
Japanese sophora (*Sophora japonica*)	2.5	American plane tree (*Platanus occidentalis*)	1.5
Horse-chestnut (*Æsculus hippocastanum*)	2.0	American linden (*Tilia americana*)	1.5
Red maple (*Acer rubrum*)	2.0	Honey locust (*Gleditschia triacanthos*)	1.0
Small-leafed linden (*Tilia microphylla*)	2.0	Scotch elm (*Ulmus montana*)	1.0
White oak (*Quercus alba*)	2.0	Cottonwood (*Populus monilifera*)	.5
Sweet gum (*Liquidambar styraciflua*)	2.0	Balm of Gilead (*Populus balsamifera* v. *candicans*)	.5
Bur oak (*Quercus macrocarpa*)	2.0	European elm (*Ulmus campestris*)	.5
Kentucky coffee tree (*Gymnocladus divisus*)	2.0	Black locust (*Robinia pseudacacia*)	.5
Sycamore maple (*Acer pseudo-platanus*)	2.0	Box elder (*Negundo negundo*)	.0

[1] This estimate of the red oak and scarlet oak was based largely on the beautiful condition of certain trees growing in the streets of Washington, D. C. Since the publication of the Yearbook article, however, several of these trees have developed rather serious cases of insect injury. The locust borer (*Xyleutes robiniæ*) has attacked a number of the trees, and although it is not apparently weakening their vitality to any serious extent, still it bids fair to do considerable damage. The trees have been treated by injecting a small quantity of bisulphide of carbon into the burrows and covering the opening with putty. In a few cases the obscure scale (*Aspidiotus obscurus*) has attacked these trees. It has not as yet killed any branches, but it multiplies as abundantly as its dangerous relative, *A. tenebricosus*, of the maple, and I see no reason why it should not be an equally injurious species. This experience somewhat shakes the confidence of the writer in his estimate of the rating of these oaks, but not to any very serious extent.

It will be noticed that the trees listed by Mr. Fernow which we find to be most immune are the gingko and the tulip tree. Outside of the grounds of the Department of Agriculture at Washington, and Central Park, New York, few gingko trees are grown in this country, except as occasional isolated examples. The tree itself is a very beautiful one, and singularly free from insect attack. In the long double row of these trees, now nearly twenty-five years old, on the grounds of the Department of Agriculture, but one species of injurious insect has ever been found, and the work of this species is very insignificant. It is the little sulphur-yellow leaf-roller, *Tortrix sulphureana.*

The tulip tree, which is given the same rating, is, for practical purposes, almost as exempt as the gingko. Of late years in the District of Columbia it has been rather extensively infested by a plant louse (*Siphonophora liriodendri*), but although the lice occur on the leaves in great numbers, the general appearance of the trees has not suffered. There is a little gall midge which produces little black spots on the tulip tree leaves and disfigures them to some extent, and quite recently Mr. Schwarz has found that tulip scrub is affected to some extent in the District of Columbia by a little bark-boring beetle.

The box elder is a singularly unfortunate choice for a shade tree in this climate. It is almost defoliated by the webworm, it is sought after by the tussock moth, and various leaf-rollers attack it as well as certain destructive borers. In the West the box-elder plant-bug (*Leptocoris trivittatus*) breeds upon it in enormous numbers, and not only damages the trees to a serious extent, but causes much further annoyance by entering houses for hibernation.

The European elm is given a low rank, almost entirely on account of its annual defoliation by the imported elm leaf-beetle.

The honey locust and the black locust, while not defoliated to the same extent as many other trees by the webworm and the tussock-moth caterpillar, are rendered very unsightly almost every year by the work of a leaf-mining Hispid beetle and of certain Lepidopterous leaf miners. They are also frequently killed by the large Lepidopterous borer, *Xyleutes robiniæ*, and certain Coleopterous borers also infest them.

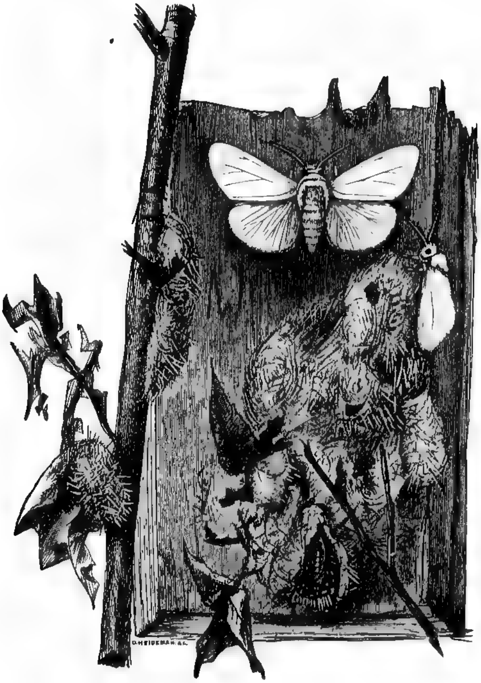
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FIG. 9.—Fall webworm (*Hyphantria cunea*). Moths and cocoons—natural size (original).

From the insect standpoint, there are several fine-growing ornamental trees on the grounds of the Department of Agriculture, not listed above, which are seldom attacked by insects. The beeches, hornbeams, alders, and magnolias have very few insect enemies, and are rarely defoliated by either of the principal leaf-eating caterpillars.

With regard to the extreme attractiveness which the European elm possesses for the imported elm leaf-beetle, the question is frequently asked whether it would not be better to cut down all European elms growing in parks or in rows with American elms. Such a course, however, would seem to be undesirable. After the elm leaf-beetle has established itself in a given locality, it will attack the American elms to a very serious extent, in the absence of its favorite food plant. It is, therefore, better to allow a few European elms to remain. These will then act as trap trees, and the necessity for treating a large number of trees will in most cases be greatly reduced.

In selecting shade trees, particularly for small cities and towns in agricultural regions, and even to a considerable extent in large cities, the relative honey-producing qualities of the proposed shade trees is a matter of some little importance; not so much, perhaps, in the matter of actual food for the ordinary honeybee as in that of the increase of bees on account of their great value as cross fertilizers of orchard trees and forage crops. From this point of view, there are five very important honey producers among the principal shade trees. These are, in order of importance: American linden, tulip tree, black locust, horse-chestnut, and sugar maple.

GENERAL WORK AGAINST SHADE-TREE INSECTS IN CITIES AND TOWNS.

The question of proper work against the insects which affect shade trees in cities and towns naturally divides itself under two heads: (1) What can be efficiently and economically done by city governments? (2) If city or town administrators will not appropriate a small amount of money to carry on work of this kind, what can citizens who are interested in the preservation of shade trees do?

The planting of shade trees seems to be considered a legitimate function of the board of public works in every municipality. It is sometimes done by a specially appointed officer, under the control of the superintendent of streets and sewers; or it is placed in charge of a subcommittee of the board, or a special commission of outsiders is appointed to superintend the work. Admitting that the planting of shade trees is a public matter, their care should also be a public duty. Yet in not one of the larger or smaller cities of the Eastern United States with which the writer is familiar is any proper amount of work done by the public authorities against shade-tree insects. New York is the only city in the country where a man of entomological knowledge is employed to direct operations against shade-tree insects, either in the streets or the public parks. The writer does not wish to be understood as advocating the appointment of a paid entomologist by every city government, although where the parks are large in cities situated within the region of greatest shade-tree insect activity, such a course is always desirable. With an intelligent and industrious superintendent of parks, or a city forester, or whatever he may be termed, and the wise expenditure of a comparatively small amount of money each year, the shade trees of any city could be kept green throughout the summer.

The amount of money to be expended in this direction would naturally vary with the number of trees to be attended to, as well as with the variety and the size of the trees and the geographical location of the city. Even in Brooklyn, however (and this seems to the casual observer to be the most unfortunate of all our Eastern cities from this standpoint), it is within bounds to estimate that the expenditure of $4,000 to $5,000 a year would result in green shade trees the summer through. This amount, moreover, will in all probability not need to be an annual appropriation. The first cost of a proper spraying apparatus will have to be added, but the apparatus once purchased and thorough work performed for two or three years consecutively, the probabilities are strong that the number of shade-tree insects would be reduced to such an extent that a considerably smaller annual expenditure would be sufficient.

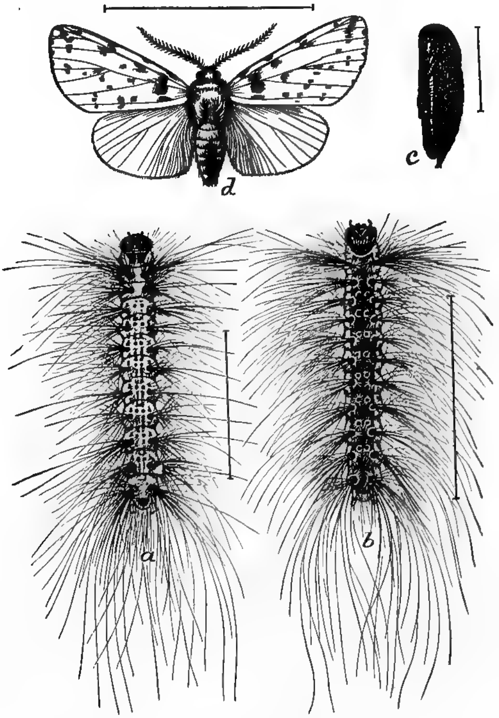

FIG. 10.—Fall webworm. *a*, light form of full-grown larva; *b*, dark form of same; *c*, pupa; *d*, spotted form of moth (compare fig. 9)—all slightly enlarged (original).

The question of proper spraying apparatus is a rather serious one, since in this direction a considerable amount of money should be expended. A steam apparatus will do the work with much greater rapidity than a hand pump; and yet with a strong, double-acting force pump, which can be operated by a single man, and a tank of 100 gallons capacity, mounted upon a strong cart, many large trees can be well sprayed in the course of a day. From such a pump two lines of hose may be run with advantage.[1] The working force of such an apparatus should be a horse to draw the cart, a man to drive and do the pumping, and one man to each line of hose. Several such machines have been used with good results in the work of the Gypsy Moth

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[1] In the Yearbook of this Department for 1896 will be found an article by the writer entitled "The use of steam spraying apparatus," to which persons interested in such matters are referred in this connection.

Commission, both for street trees and in the public parks. A steam apparatus, however, of such a capacity that a pressure of 75 pounds per square inch may be gained will enable the operation of four or five lines of hose simultaneously. The rapidity of work will therefore be doubled, and certainly by the use of two such pumps the shade trees of any ordinary city can be gone over with sufficient rapidity to destroy all insects within the required time. A boiler mounted on a truck, the boiler to be complete with all fixtures, smokestack, bonnet, firing tools, springs to the truck, and a pump having a capacity of from 10 to 20 gallons a minute connected with the boiler ready for operation, can be purchased for a sum well within $500. This truck should be mounted on wheels with broad tires, for running over sandy roads.

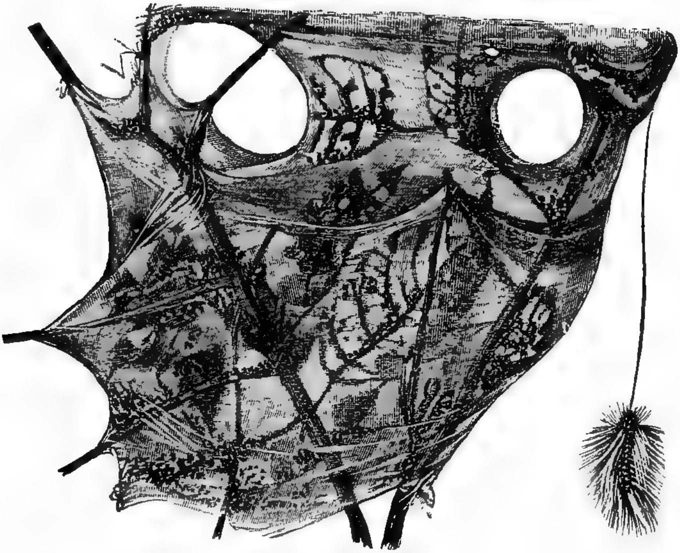

FIG. 11.—Fall webworm. Suspended larva and section of web—natural size (original).

Connecting this apparatus with a proper tank cart would be an additional expense, not to exceed $100 for a tank of a capacity of 200 gallons. Such an apparatus, furnished with hose and smoothbore nozzles of about one-sixteenth inch in diameter, when discharging under 40 pounds pressure from each of several such nozzles, would spray about half a gallon of insecticide mixture per nozzle per minute.

A strong steam pump, to be used in connection with a small oil-burning boiler, the whole apparatus on a smaller scale than that described above, has been estimated at $275 by a prominent New York firm, delivered on board the cars.

There is no reason why an old steam fire engine could not be readily arranged for this shade tree spraying work. In one or two instances a steam fire engine has been used for this purpose without modification, the object being simply to knock the insects from the trees by means of a strong stream of water. By such means as this the Superintendent of the Military Academy kept the elm trees green at West Point several years ago. In every large city, where the fire department is necessarily kept in the best condition, an engine is occasionally retired. The transfer of such a retired engine to the street department could no doubt be readily made, and a little work by a competent steam fitter could transform it into a most admirable insecticide machine. In this way the initial expenditure for machinery would be avoided.

When the spraying apparatus has once been provided, the funds necessary for the purchase of insecticides and the necessary labor at the proper time must be available. If the work is not done promptly and at just the right time, more or less damage will result, and a greater expenditure will be necessary. During the latter part of May and the first part of June, in the case of nearly all prominent shade-tree insects, one or two thorough sprayings must be made. In fact, a a second spraying, begun immediately after the completion of the first one, will in ordinary cases be as much as need be expected. In addition to this spraying work, a force of men must be employed for a time in July to destroy the elm leaf-beetle larvæ as they are descending to the ground and to burn the webs of the first generation of the fall webworm. This will finish the summer work. The winter work will consist of the destruction of the eggs of the white-marked tussock moth, the cocoons of the fall webworm, and the bags of the bagworm. The number of men to be employed and the time occupied will depend upon the exigencies of the case. Upon the thoroughness of this work will depend, to a large extent, the necessity for a greater or less amount of the summer work just described.

We have now to consider what can be done by citizens where city governments will not interest themselves in the matter. It is unreasonable to expect that a private individual will invest in a spraying apparatus and spray the large shade trees in front of his grounds. Therefore, in spraying operations where large trees exist in numbers there must be combination of resources. This affords an opportunity for the newly invented business of spraying at so much per tree. A resident of Bridgeport, Conn., who was formerly, and is yet for the greater part of the year, a roofer and paver, has constructed several cart sprayers, and during the months of June and July (at a time, by the way, when the men in his employ are apt to be out of work) he sprays trees on the grounds of private individuals and along the streets in front of their grounds, under contract, at so much per tree, guaranteeing to keep the trees in fair condition during the season. His work has been directed solely against the elm leaf-beetle, since that is the only insect of great importance in Bridgeport. In the month of July, 1894, the writer, in driving through the streets of

Bridgeport, found it easy to pick out the trees which had been treated in this way. Such elms were green, while all others were brown and nearly leafless. The defect of this plan as a general practice lies in the fact that not all property owners or residents can afford to employ a tree sprayer, while others are unwilling, since they deem it the business of the city authorities, or do not appreciate the value of tree shade.

Any effort, therefore, looking toward the arousing of popular sentiment or the banding together of the citizens in the interests of good shade is desirable. A most excellent plan was urged by one of the Washington newspapers in the summer of 1894. It advocated a tree-protection league, and each issue of the paper through the summer months contained a coupon which recited briefly the desirability of protecting shade trees against the ravages of insects, and enrolled the signer as a member of the league, pledging him to do his best to destroy the injurious insects upon the city shade trees immediately adjoining his residence. This is only one of several ways which might be devised to arouse general interest. The average city householder seldom has more than a half dozen street shade trees in front of his grounds, and it would be a matter of comparatively little expense and trouble for any family to keep these trees in fair condition. It needs only a little intelligent work at the proper time. It means the burning of the webs of the fall webworm in May and June; it means the destruction of the larvæ of the elm leaf-beetle about the bases of elm trees in late June and July; it means the picking off and destruction of the eggs of the tussock moth and the bags of the bagworm in winter, and equally simple operations for other insects should they become especially injurious. What a man will do for the shade and ornamental trees in his own garden he should be willing to do for the shade trees 10 feet in front of his fence.

KENTUCKY

AGRICULTURAL EXPERIMENT STATION

OF THE

STATE COLLEGE OF KENTUCKY.

BULLETIN No. 47.

1. THE PESTS OF SHADE AND ORNAMENTAL TREES.
2. AN EXPERIMENT ON PLUM ROT.

LEXINGTON, KENTUCKY,
DECEMBER, 1893.

KENTUCKY

Agricultural Experiment Station.

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Address:
KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KY.

BULLETIN NO. 47.

I. THE PESTS OF SHADE AND ORNAMENTAL TREES.

BY H. GARMAN, ENTMOLOGIST AND BOTANIST.

Trees are subject to many different injuries, from insect enemies, from parasitic fungi, from unfavorable conditions of surroundings, from severe droughts, sudden lowering of the temperature, etc., and require like other plants some care and attention in order that they may grow well. They need this attention especially when grown about dwellings for shade, since the exposure to weather, and the facility with which their enemies can concentrate on them and spread from tree to tree makes them more liable to injury then when scattered and growing in a state of nature. Often several causes leading to the decline and ultimate destruction of shade trees are at work at one and the same time, and it becomes then a matter of some difficulty to discover the primary cause, and to check the injury. It may be that the soil was not suited to the needs of the trees planted, and that they exhausted the available supply of nutriment, then suffered from starvation, if I may use the word, in which condition plants are well known to be much more liable to the attacks of fungus and insect enemies than when in perfect health. In such cases, however, the insects are liable to get the blame for the injury, and while there is no doubt that they increase the injury and may ensure the ultimate death of trees which would not otherwise succumb completely, it is evident that their removal will not entirely answer the requirements of the case. The proper thing to do for trees suspected to be in need of nourishing material at the roots is of course to supply the food in the form of a fertilizer. The material taken from the earth by thrifty trees is very considerable, as may be known from the fact that other plants of vigorous growth and large size will not grow well near them. In the forest and thicket they get this nourishing material from the decay of fallen trees and leaves, and from the annual growth of surface vegetation. Along the streets of a city and on a well groomed lawn the supply from sources such as these amounts to but little, and it is therefore the part of wisdom to supply the deficiency of artificial means.

Considerations of this sort come strictly within the domain of practical horticulture rather than in that of economic entomology and botany, yet it is not possible to separate by hard and fast lines these different lines of work and study, so intimately are they bound up with each other. Inquiries sometimes reach the Experiment Station concerning "diseased" shade or fruit trees which it is evident are suffering from a period of neglect on the part of the owners. It requires heroic measures to rescue trees which have exhausted the nutriment within reach of their roots, which are besides bored through by the larvæ of beetles, and whose leaves are gnawed by web-worms, and it may be also infested with aphides and parasitic fungi. And while for advanced cases of disease of this sort it is only to be recommended that the trees be cut down and burned as promptly as possible to prevent further spread of the insect and fungus pests, this is a measure people are very reluctant to take, and it is one consequently an entomologist does not like to recommend (though it may be evident to him that in the long run this would be economy both to the owner and his neighbors.) Until the State enforces by law the destruction of such infested trees, we cannot, therefore, hope for the prompt and drastic measures often needful for stamping out the pests to which vegetation is subject.

Injuries should be checked at their Inception and Precautionary Measures should be adopted.

It is sometimes possible to prevent the increase of an injurious insect with but slight trouble if we know exactly what it is, and when our work may be most profitably done. The cutting away and burning of an infested branch, the removal and destruction of an entire tree, sometimes even the removal of a single insect, may save the trees of a whole village from severe injury. Always dead portions of trees either on the trees or lying on the ground are to be removed and disposed of. Weeds and rubbish calculated to afford lurking places for insects ought always to be removed, and loose dead bark on the trunks should not be allowed to remain. Though to many people a whitewashed tree trunk is an unsightly object, there can be no question as to the value of such treatment for some injuries, and the wash may be made even more effective by adding to it London purple or Paris green, when the "tombstone effect" of which some people complain will be done away with.

It is a matter of common observation that the man who attends to these things is much less troubled by injury to trees than one who neglects his grounds. Still there is a class of injuries which no one can be accused of encouraging, and which it is very desirable to control if possible. Sudden frosts after the sap begins to flow in spring may result in injuries not in themselves very serious, but which open the way to attacks by insects. Sleet and wind storms may occasion injuries which in the nature of things cannot be avoided. Droughts when prolonged often weaken trees which are not very vigorous, or are badly situated, and then insects when encouraged by very favorable weather, will overrun a place in spite of all the ordinary precautions that may be taken, attacking in such cases the more thrifty trees, as well as the enfeebled ones.

Sunstroke of Trees.

In considering the nature of injuries suffered by shade and ornamental trees we must not omit mention of an injury which is very common in Kentucky, and often very destructive. I refer to that sudden blighting of trees with rather succulent foliage, which occurs in hot weather in July. Trees seemingly in perfect health, with splendid growths of leaves receive a check which in its suddeness and effects can only be likened to sunstroke. The crisp green leaves wither on most of the branches in a day, and ultimately blacken and dry up as if the tree were utterly killed. After a time such trees partially or wholly recover and put out a new growth of leaves before fall, still, however, by their enfeebled condition showing that the shock was a severe one. When I first observed this trouble among trees, I supposed it might be due to attacks from some one of those minute organisms known as bacteria. The dying leaves show no trace of ordinary parasitic fungi such as occasion the mildew of grape vines and the scab of apple. But careful examination of the tissues when first affected shows no bacterial or other

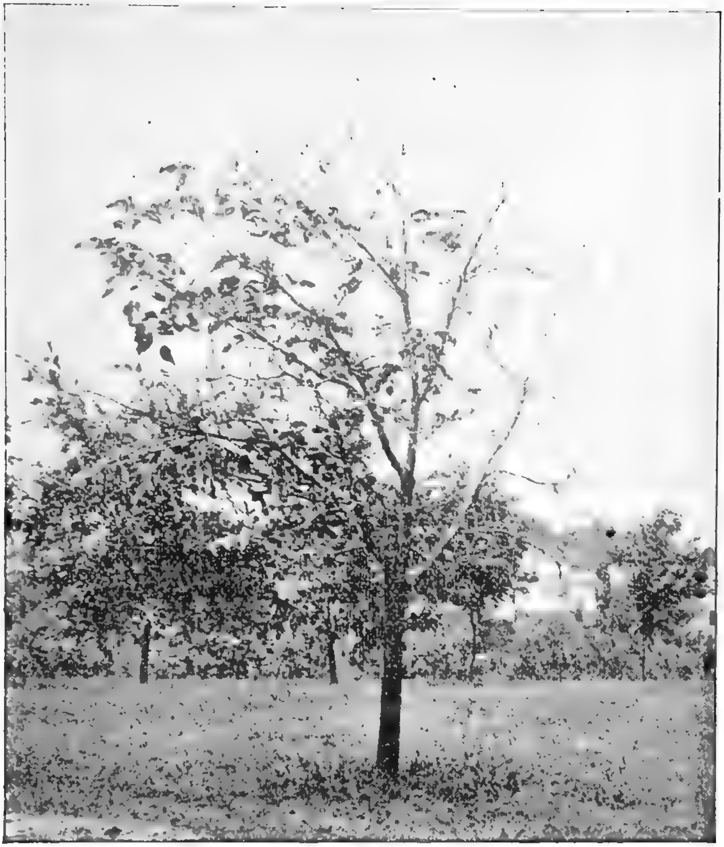


FIG. 1. Showing a catalpa tree, the foliage of which has been partially destroyed by heat. From a photograph.

organisms present that could possibly occasion such sudden and extensive injury, and after repeated attempts to induce the disease by inoculation, I am forced to believe that conditions of weather, such as showers followed by extreme heat, occasionally kill the foliage of some of our shade trees. The tree which has suffered most in this neighborhood during the past three years is the Catalpa, and I present herewith a figure of one of these trees as it appeared soon after it became affected. One of my purposes in calling attention to this trouble is to point it out as an affection not due to insects, and not very easy to guard against. Inquiry has reached me occasionally with reference to it. I do not know anything likely to prevent its occurance except shade; and I am disposed to think that the trees which are subject to it are those whose habit it is to grow in thickets, and which are not therefore adjusted to complete exposure to the sun's rays.

Kinds of Pests Attacking Shade Trees.

The parasites of our shade and ornamental trees are of two sorts: insect and fungus. The latter are only occasionally abundant enough to call for attention. But they may during warm damp seasons do quite as much harm as insects. Their attacks are most generally made on the leaves and tender growths of twigs, where they produce variously colored spots and blotches, and in the end kill the tissue. The soft maple (*Acer dasycarpum*) and red maple (*A. rubrum*) are subject to the attacks of a fungus (*Rhytisma acerinum*) in the Mississippi valley that often works much injury to the leaves. It produces a dense black spot varying from .25 to .50 inch in diameter, with its upper surface coarsely wrinkled and slightly convex. The leaves of the yellow poplar (tulip-tree) are also subject to the attacks of a fungus producing small black dots and spots eventually resulting in extensive discolorations. The black oak (*Quercus coccinea*) sometimes bears on the upper surface of its leaves numerous ash-gray blotches of irregular size, which when closely examined are found to be minutely speckled with black. They are the results of the growth of another fungus (*Microsphæra quercina*), which preys upon the growing foliage of this oak. And so through the whole list of shade and forest trees, there are very few species that are not subject to one or more of these fungus parasites. The elms, the basswoods, the hickories, the walnuts, all have their peculiar species.

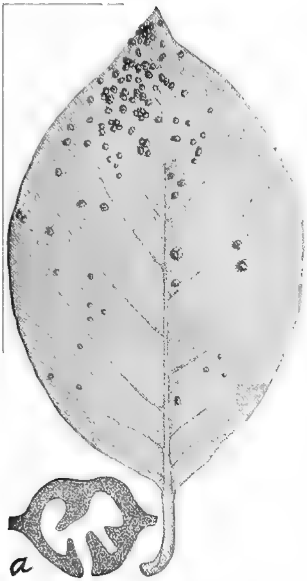


FIG. 2. Showing leaf of black gum galled by minute mites *a*, section through one of the galls. Soft maples show a similar injury.

With such numbers of enemies, insect and fungus to drain them of sap and destroy their foliage it might seem that trees would more frequently be destroyed. This result would probably be witnessed more often were it not for the fact that the leaf-eating insects are most common as a rule during dry seasons (this does not appear to be true of insects which live in the interior of plants), while the fungus enemies are most injurious when the rainfall is greatest. Their prevalence being thus alternating to some extent, the trees do not so often suffer from attacks of both at one and the same time.

The insect pests are the more frequently destructive, and at times so completely strip the leaves from elms, maples and other trees as to threaten their extermination. They may be divided roughly into three groups, according to the part of the tree they attack, as follows: (1) Leaf insects, (2) trunk and branch-mining insects, and (3) root-infesting insects.

The first group of the three includes most of the species which attract general attention, though it cannot be said that they are the most destructive. To it belong the fall web-worm, the walnut-worm, and the elm leaf-beetle so destructive in the eastern states. To it also belongs the Gypsy-moth, for the destruction of which the State of Massachusetts during the three years ending December 31, 1893, expended $175,000. Such insects attract attention at once from the nature of their injury, the unsightly appearance due to gnawed leaves, webbing, and refuse, taking away at once from trees their practical value, as shade, and their esthetic value, as ornament.

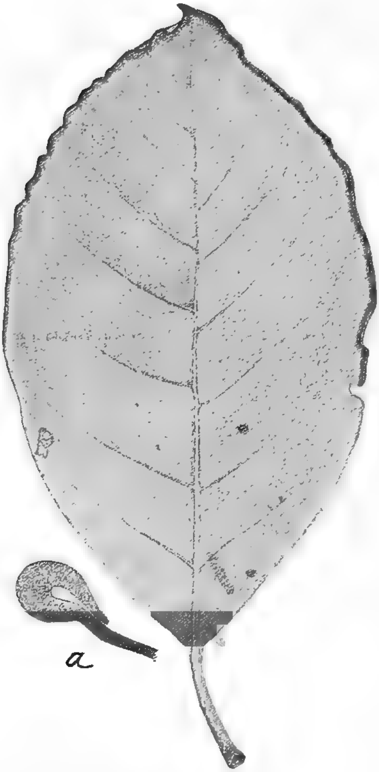


FIG. 3. Showing a marginal gall produced by mites on black gum.

While their injuries are not at first so apparent, the work of the boring and mining species is not less injurious, and is the more to be feared because its results are not seen until the mischief under the bark is at an advanced stage. The locust borer and the elm bark-beetle are members of this group, both species being common and injurious in Kentucky. The pine bark-beetles and the fruit bark-beetles now becoming injurious in this State may also be placed here. The greater number of species which attack the trunk are the grubs of beetles. A few are caterpillars (larvæ) of moths. The branches and twigs are injured by a host of small species, some of which girdle them, others mine them, still other species do serious mischief by placing their eggs in them, while some of the true bugs simply puncture and abstract their sap.

Doubtless the number of insects which feed on the roots of shade trees is large, but the unavoidable difficulties in the way of studying their habits has prevented a very full knowledge of this group. Among the better known is the 17-year cicada (*Cicada septendecim*) which in its immature condition lives in the earth where it doubtless punctures the roots of oaks and other trees. A few root-feeding beetles are also known to attack trees, but our knowledge concerning their habits is much too scanty.

The insects belong in great part to the following orders, which I have arranged according to their importance as enemies of trees. The moths are placed first with some question, since the beetles are often locally the more destructive, and are especially injurious to cone-bearing trees, upon which the moths do relatively little mischief.

Moths and Butterflies (Order Lepidoptera). This group includes all the caterpillars, such as the canker-worms, walnut-worms, and the like, with well developed heads and legs Their bodies are often hairy. They live exposed on the leaves, or construct webs, while some of the small species mine the leaves or twigs. A few bore the trunks. The adult moths are not in any way injurious.

Beetles (Order Coleoptera). The insects of this order injure trees both in their immature and mature stages. The adults are hard-bodied insects, well known under such names as June-bug and potato-bug, while their young are known as grubs, those attacking trees having well developed heads but often no legs. Their bodies are generally thick and stout, and are more or less U-shaped in many cases. They attack roots, trunk and leaves.

True Bugs (Order Hemiptera). A large number of this group of insects attack the foliage and tender growths of twigs, and a few such species as the 17-year locust (cicada) suck the sap from the roots of trees. All such insects are provided with a piercing proboscis, and feed at all stages of their growth upon the sap of plants. The order includes, besides the 17-year locust, such species as the plant-lice (aphides), the bark-lice, the various tree-and leaf-hoppers, and the plant-bugs (Capsidæ) the latter sometimes very destructive to young fruit trees.

Sawflies and Bees (Order Hymenoptera). In the grub state some of these insects gnaw away the leaves of trees and other plants, while other small species gall the twigs and leaves. The sawflies, including the elm sawfly, the currant-worm, and the like, are our most destructive species. The adults do little mischief of any sort, and many species are beneficial by helping to fertilize flowers of useful plants.

Flies (Order Diptera). In their adult state these are two-winged insects such as the housefly, mosquito, and buffalo-gnat. When not mature they are known as grubs, maggots and wrigglers. Though sometimes very annoying to man and the domestic animals, the winged adults do no harm to vegetation. The grubs of a few small flies and gnats live in galls or mines in the leaves and twigs of trees, while a few others mine seed-pods, and other kinds of fruit. The grubs may be known from all other kinds which infest trees by the absence of legs and of a head.

Katydids and Grasshoppers (Order Orthoptera). We have a number of katydids (though all do not have the well known note that has given rise to the name) and tree crickets in Kentucky that spend most of their time among the foliage of trees. They are, however, usually so scattered that but little apparent harm results from their presence. Some of them, such as the true katydid, are strictly tree-dwellers. The members of this order have no grub state, but have the adult shape when hatched, and change subsequently only in size and by acquiring wings.

Trees Least Injured by Insects.

It is evident to everyone accustomed to notice trees closely that the species differ considerably in their susceptibility to insect attacks. Some, like the black locust, the walnut, the apple and the soft maple, are generally infested with a larger or smaller number of injurious insects, without regard to locality, while others such as the buckeyes and hard maple, are relatively but little injured. And while it is true that as a general thing insects attack by preference such vegetation as is most nutritious and edible, and consequently likely to prove useful to us, this fact is mainly of importance in considering plants which bear flowers or fruits of value, and has not the same importance in considering shade trees. A tree may present a fine appearance, and yet its leaves and fruit be noxious. It does not follow though because a tree is not injured that it is in any way noxious to man. Some of our very finest native trees would come under condemnation if this were true. I have never heard of anything hurtful in the leaves of the tulip-tree, sweet gum, or sugar maple, all good trees for planting.

The central fact to be noted in this connection is that certain of our trees are less subject to insect injury than others, and that it is possible by selecting judiciously to have, much of the time, trees with clean whole leaves without resorting to the use of insecticides and fungicides.

Trees Most Subject to Insect Injury.

As to trees most subject to injury we may mention for this locality the poplars, box-elder, and black locust, all of which are very badly denuded of their leaves at times by caterpillars. The box-elder while a rapid grower, is not as valuable for shade as are many other trees, and can perhaps be spared. Some of the poplars are very handsome, especially when young, and something should be done to protect them. The black locust, with its fragrant blossoms, is so pleasantly associated with spring, that it seems ungracious to say anything against it. Yet the plain truth is that it is not remarkable either for beauty or shade, and its leaves are attacked by a small army of insects that give it a draggled and unpleasant appearance in the latter part of summer. Its trunk too is mined by several destructive borers. If ash, elm, or hard maple had been planted in place of most of the black locusts in the State the appearance of our country homes and roads would be greatly improved.

Methods of Treating Shade Trees.

For all insects that gnaw the leaves it is possible to apply mixtures which will serve to defend trees very effectively from injury. The chief difficulty comes from the labor required and the cost of apparatus. If trees threatened with injury from tent-caterpillars, fall webworms, walnut-worms, elm leaf-beetles, or any one of the score of leaf-eating pests known to us, are thoroughly sprayed with water containing Paris green or London purple, their leaves are rendered proof against any very serious injury, and when it is possible to employ a suitable spraying pump this treatment is to be strongly recommended for all such enemies of trees. With young trees there need be no difficulty. These can be easily sprayed from the ground, or by mounting a barrel or tank, with force pump attached, on a wagon or cart.

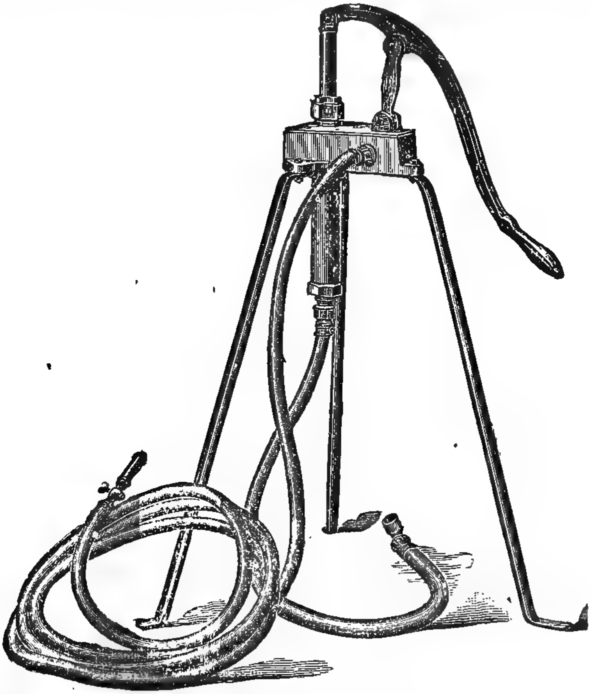


FIG. 4. The improved Nixon Climax pump, for spraying.

The outfit for spraying orchards commonly used answers very well also for this purpose. When large trees are to be sprayed, strong pumps must be used, together with a sufficient length of hose and some means of elevating the distributing nozzle. It is a common practice to employ long poles for this latter purpose, simply attaching the nozzle to one end by wrapping it with twine. A large bamboo rod with the septa burned out to permit the hose to be passed up through it, has been recommended for this same purpose and has advantages of lightness and convenience in its favor. For exceptionally tall trees it is necessary to employ besides, a ladder, and occasionally it may be necessary to throw a solid stream of the fluids used, trusting to the friction against the atmosphere to break it into a spray. Some of the nozzles sold for this work are so constructed that the cap concerned in producing the spray can be removed, thus permitting a single stream to issue, which is thrown to a greater distance. The spray itself may be thrown horizontally by means of some of these pumps and nozzles a distance of 25 feet. Thrown vertically, or nearly so, it would not go so far, hence the occasional necessity of the other method for reaching the leaves.

The quantity of poison to be used varies with the kind of trees to be sprayed. For apple trees it is customary to use 1 pound of either London purple or Paris green in from 160 to 200 gallons of water. We have used the former proportion (1 lb. to 160 gallons) at the Experiment Station, with little or no injury to the leaves. To avoid the danger of damaging the leaves it is well to experiment on a branch, or at most a single tree, before doing more extensive spraying, remembering however, that the poisons may not show their destructive effects on either leaves or insects until several days have elapsed. These poisons lose none of their effectiveness as insecticides when mixed with wheat flour, and the addition of the flour renders the mixture more adhesive and less injurious to the leaves, hence it is well to use the two in combination where possible. For spraying the leaves of elm trees Dr. C. V. Riley recommends, after some exper-

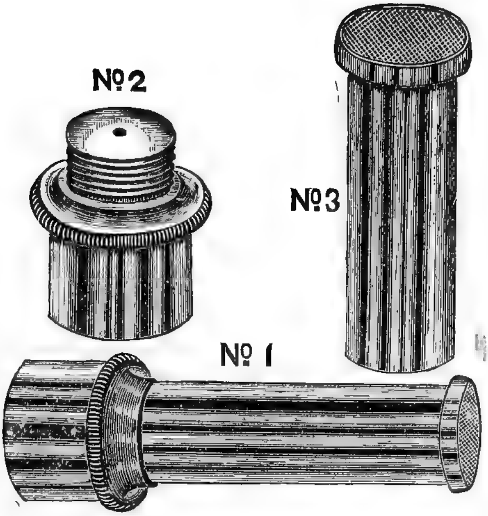


Fig. 5. A good form of nozzle. No. 1, the complete nozzle. No. 2, the nipple, unscrewed so as to show small opening for escape of fluid. No. 3, the cap with wire screen at end for breaking fluid into a spray.

ience in spraying these trees about the city of Washington, London purple, one half pound, flour 3 quarts, water 40 gallons. He considers one-half to three-quarters of a pound of the poison in 40 gallons (one barrel) of water about the maximum strength to be used with safety.

Insects which puncture the leaves of trees cannot be destroyed with mixtures of London purple or Paris green. It is true that these poisons when applied to the bodies of some insects have a destructive effect, but used in quantities sufficient for this purpose, they are liable to injure foliage. For bark-lice, plant-lice and leaf hoppers, all of which puncture and suck the sap of plants instead of gnawing away and eating the substance, it is therefore necessary to use other preparations. These must kill when brought in contact with the body of an insect, and moreover must do this without injuring the leaves.

Among substances employed for this purpose coal oil (kerosene), Persian insect powder (pyrethrum), buhach, and white hellebore, are well known for their effectiveness. A "resin compound," more recently recognized as useful, is now used successfully for scale insects on orange trees, in the West, and is highly recommended by some of our best authorities on the treatment of such pests. The methods of preparing and using such insecticides have been so frequently considered in Station reports that it is not necessary to go into detail here. Those especially interested in these matters will find a condensed account of the insecticides and fungicicdes in common use, in Circular No. 3, of this Experiment Station. As a matter of convenience I will, however, give the formulæ for making the two preparations best calculated, by virtue of their cheapness and effectiveness, for use on trees.

Kerosene, or coal oil, is now everywhere applied to plants as an emulsion, which may be prepared as follows: Dissolve one-half pound of cheap soap in a gallon of hot water, then while still hot add to this two gallons of kerosene, and finally pass the whole through a pump, returning it with force to the vessel whence it is being pumped up. In a few minutes it will assume the appearance of cream, and if the churning has been thoroughly done it will retain this consistency and [appearance. It is in fact an emulsion, and in this condition the oil may be mixed with water in any proportion. Herein consists its advantage over pure coal oil. It may be so diluted that it will do no injury to leaves, but still retains all its properties as an insecticide.

Mr. Kœbele who has perhaps had as much experience with the resin compound as any one, recommended a few years ago the following formula for its preparation:

Sal-soda, 3 lbs.
Resin, 4 lbs.

Water, 3 pints.

Dissolve the soda and resin in the water by heating. While boiling add water slowly until the whole makes 36 pints. To use add 8 parts of water to 1 part of the above Stronger mixtures have been used, but may do injury when not carefully applied. 3 pints of the compound to 4 of water is about the maximum to be used with safety.

Mr. Coquillett, an agent of the Division of Entomology at Washington, has also worked with this compound and gives the following as the result of his experiments with one of the scale insects of fruit trees in California.

Caustic soda (70 per cent), 9 lbs.

Resin, 30 lbs.

Fish oil, 4½ lbs.

Water, enough to make 100 gallons.

He advises the use of a kettle holding 30 gallons for making the compound. All the materials are placed in this and after covering them to a depth of 4 or 5 inches with water, they are dissolved and then boiled for two hours, or "until it will dilute evenly with water, like black coffee." At this stage the kettle is slowly filled with water and when full may be emptied into a tank or barrel where the remainder of the water can be added. Any sudden chilling of the preparation by the addition of large quantities of water is, he says, to be avoided. It would seem from Mr. Coquillett's work that the compound destroys the insects by forming a sort of varnish on their bodies thus choking up their breathing pores and smothering them. The soda is useful consequently only by virtue of its action in the resin and oil, and no more should be employed of this ingredient than is necessary, because of injuries to foliage when the proportion used is large.

On our west coast the use of gas for destroying scale and other insects on fruit trees is considered by those who have worked with it, the most efficacious treatment, and is now superceding the use of washes. When it is remembered that many of these scale insects are protected by a shell, not unlike a minute turtle's shell, all the limbs and other parts being small and concealed, and that the edges of this are commonly kept closely applied to the leaves or twigs it will be understood that it is no easy matter to apply fluids by spraying so as to reach vulnerable parts of these insects. It is true, none the less, that the resin compounds and preparations of kerosene are very useful for this purpose, especially where the number of trees to be treated is small, and applications can thus be made repeatedly and thoroughly.

Gas, however, penetrating as it does every crevice about the trees is calculated to destroy all insects it reaches, and experiment shows that it will destroy their eggs as well. In applying the gas it is, of course, essential that the trees be enclosed. For this purpose Mr. Coquillett recommends large octagonal sheets made in great part of eight ounce duck, the two middle breadths upon which the strain comes in handling, being made of ten ounce duck. These may be rendered gas-tight by painting with linseed oil, or a thin paint made of yellow ochre, and are placed over small trees by means of poles, or over large ones by means of a special derrick mounted on a wagon.

The hydrocyanic acid gas, now generally employed, is generated in an open earthen vessel placed under the enclosing tent or sheet. The ingredients employed are: Undiluted commercial sulphuric acid, 1 fluid cz.; undissolved, fused potassium cyanide, 1 oz. by weight; cold water, 3 fluid ounces. The water is poured into the vessel, then the acid follows, after which the vessel is placed on the ground in the tent, and the potassium is added, and the openings at the ground are closed. The materials for generating the gas must vary in quantity with the size of the tree, and the thickness of its foliage. The time necessary to destroy insects ranges from fifteen to forty minutes. Mr. Coquillett thinks the best time to apply gas is at night or during cool and cloudy days when the life processes of the trees are least active.

It is not likely that this method of treating trees will soon be employed for large shade trees; for small ones, for nursery stock, and for some fruit trees, it is admirably adapted, and I have called attention to it here because it will doubtless be found in special cases to be the most convenient means of checking injury. Those who may be especially interested in the process will find an excellent condensed account of it in Vol. VI, No. 2, p. 176 (1893) *Insect Life*, printed by the Department of Agriculture at Washington.

Many other ways of treating trees for injurious insects have been advocated, some good, others of no value whatever. Among the latter may be mentioned the plan of boring holes in the trunks of trees and filling them with sulphur. Tarred bands are sometimes employed to prevent the ascent or descent of injurious insects along the trunks. Whether the bands prove of value or not depends of course upon whether the insect has other means of getting to the leaves than by creeping up the trunk. They can be of little use in checking the injuries of such pests as fly to the leaves, though they have sometimes been recommended and used for such species. For the canker-worm and some others which habitually creep up the trunk the tarred bands can in some cases be used profitably, but even for these spraying, if practicable, is the better treatment. When bands are used the tar must be kept from the trunks by strips of tin, otherwise it may injure the trees. Bands of straw, old carpet, or other material are sometimes used also as traps for insects which leave trees for pupation among rubbish on the ground. Such larvæ often collect under these bands in large numbers, even those which let themselves down from the branches by means of their silken threads returning in considerable numbers to the trunk to undergo their changes. This habit, it has been claimed, explains the fact that when several bands are used at different heights on the same tree, the lower generally harbors the most insects.

Some insects, as for example the elm leaf-beetle of the eastern states, will not stop under bands, their habit being to undergo their changes under rubbish, or in the ground. A box with a cement bottom, enclosing the base of the tree and a wide strip of tin covered with tar or other adhesive substance tacked to its upper edges effectually confines such pests and renders their destruction easy. The box is I believe a device first employed by the entomologist Townend Glover.

In the special matter following I have included only the notable insects which injure shade trees in Kentucky. Those mentioned do the greater part of the mischief from which our trees suffer during ordinary seasons. A large list could be given of other species which frequent shade trees for one purpose or another, some injurious in their tendency, some beneficial, some as far as we know neither one nor the other. It could only encumber a paper of the character of the present one to include these insects, which may therefore be left until they show themselves entitled to attention.

The Fall Web-worm.

(*Hyphantria cunea*).

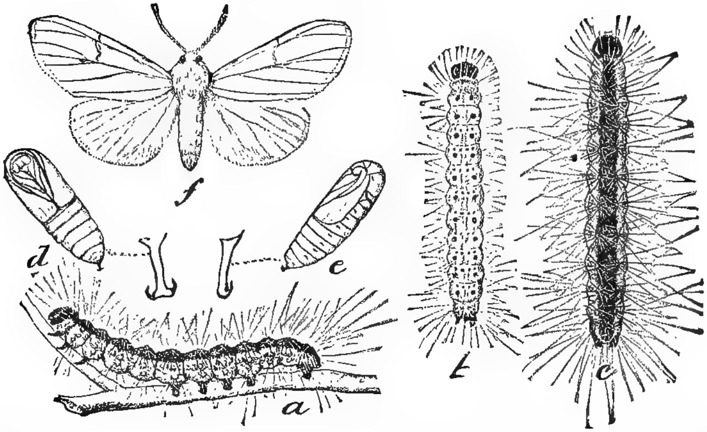


FIG. 6. Fall web-worm. *a*, side view; *b* and *c*, light and dark colored larvæ seen from above; *d* and *e*, different views of pupa; *f*, moth. (From the Division of Entomology at Washington).

This insect is known everywhere by the webs made by the worms. These are placed in the smaller forks of branches or include the terminal twigs and leaves. They are especially common towards fall.

The web is a rather loose affair including many leaves and twigs eventually, in which the worms remain at all times, simply extending it and including fresh leaves when the supply already enclosed has been exhausted. In this habit of remaining in the web they differ from the tent-caterpillar of apple trees, with which they are sometimes confounded. The greater part of the mischief done to trees occurs in the latter part of summer and is the work of the second brood. An early brood which appears to be especially fond of osage-orange makes its appearance as soon as the leaves unfold. Examples kept by me in a box indoors, went into the ground to pass the winter during the latter part of September and first half of October, the last to change to a pupa being observed preparing for the change October 19. These examples began to appear as adult moths February 18, 1892, and continued to come out at intervals until April 2.

The species does not hibernate in all cases in the pupa state, some examples of the moth coming up from the ground in the fall and hibernating in this condition. During the season of 1893 examples which were noted as changing rapidly to pupæ on August 2, yielded two adults, one on the 13th and the other on the 16th of September, the remainder of the colony continuing in the pupa state.

The eggs of the brood are placed on the leaves as soon as the latter develop, and during June the webs may be found, though they seem never to become so common at this season as they do later.

The worms may be found in such webs until the first of July, when most of them leave to undergo the next change in the ground. Examples kept by me began to change on July 8, and the moths began to come out of the earth July 15. On the 28th of July the female moths were observed placing their eggs on leaves of elms for the second brood.

During the year 1890 this pest was especially abundant and injurious in Kentucky, as the following quotation from notes made by me on September 4 will show:

Very abundant on a variety of trees, including osage-orange, elm, maple, honey-locust, and black locust, and has done a good deal of damage during the dry spell just passed. Some of the smaller trees are completely stripped of leaves, not the slightest trace of green being visible. Most of the worms are fully grown and are leaving the trees for the ground, or for other vegetation, in the latter case taking to weeds and almost anything green. Near Providence to-day they were found to be badly affected with *Empusa grylli* (a parasitic fungus), probably 50 per cent. being attacked. These diseased worms collect on the terminal twigs of poke-root, ragweed, and on the ends and knots of rails, where they die, become swollen, rigid, and finally show the characteristic powdery coating indicating the presence of mature spores of the parasite on their skins. The disease will materially lessen the numbers of this insect for next year.

REMEDIAL TREATMENT.

Tho above prediction proved right, and the insect, thanks to the parasite, has not since been so common. Yet it is still with us, and may at any time become abundant, hence the need of watchfulness. When the webs are within reach it is possible to destroy them and their occupants by simply applying burning paper. This does some little damage to the twigs, but the tree suffers less than it would from the worms, and further spread of the insects may be thus checked. When a pump is at hand the worms may be destroyed by spraying the infested branches with London purple mixed with wheat flour and water. The poison of this mixture remains for some time on the leaves so that the destruction of the worms is only a matter of time.

The Bag-worm.

(*Thyridopteryx ephemeræformis*).

This worm is the young (larva) of a moth. It lives in and carries about with it a case made of silk, on the outside of which it fastens bits of leaves, probably to render its detection less easy to birds and other enemies. One may see these cases all through the winter adhering to the naked twigs of both deciduous and evergreen trees, the worms having taken the precaution to fasten them there by wrapping the twigs with silk. The case of a

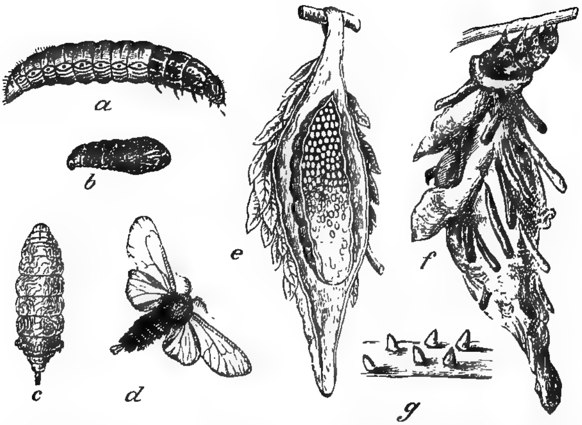


FIG. 7. The bag-worm. *a*, larva; *b* pupa; *c*, adult female; *d*, adult male; *e*, bag containing eggs; *f*, bag containing larva; *g*, young larvæ, with conical cases. (From Riley).

grown worm measures 1.75 inch in length and its greatest diameter is somewhat more than .50 inch. If cases are examined during the winter a large number will be found empty, these being old ones which adhere to the twigs longer than one season, or else are those which produced males. In every one which produced a female the preceding summer will be found an oblong brown cylindrical object tapering a little at one extremity, but blunt and with a ragged opening at the opposite end through which the adult insect escaped; for these are the deserted pupal skins of the female. Each appears at first to be full of a powdery material, but on removing some of this the minute soft whitish eggs will be observed packed closely so as to fill the greater part of the skin.

The adult female of the bag-worm is a very singular creature. looking more like a worm than a moth, incapable of flight, having no rudiments of wings, and with only minute and functionless legs. The very scales of the greater part of her body are abortive, and are rubbed off to constitute the powdery material in which the eggs are packed. Being incapable of flight the most she can do as to wriggle down to the opening at the lower end of her case where she meets the winged mate, and then in the same manner wriggles back to her empty pupa case in which she carefully places her eggs for safe-keeping during the winter. Finally, with an astonishing solicitude for the welfare of her prospective young, she deserts the case, drops to the ground and dies shortly afterward. Is it possible that this pulpy mass, exhausted, with nothing more to live for, with death certain and at hand, understands that a dead and putrid body left in the case would work harm to her precious eggs? Anyway she leaves the case.

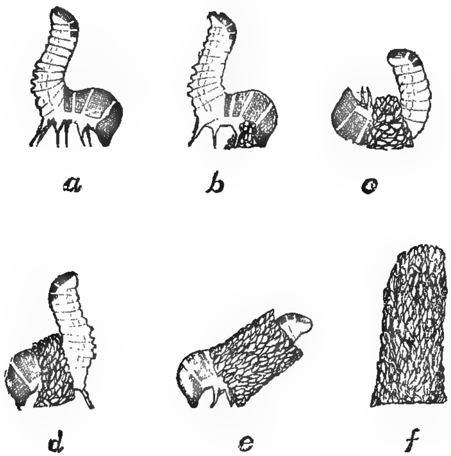
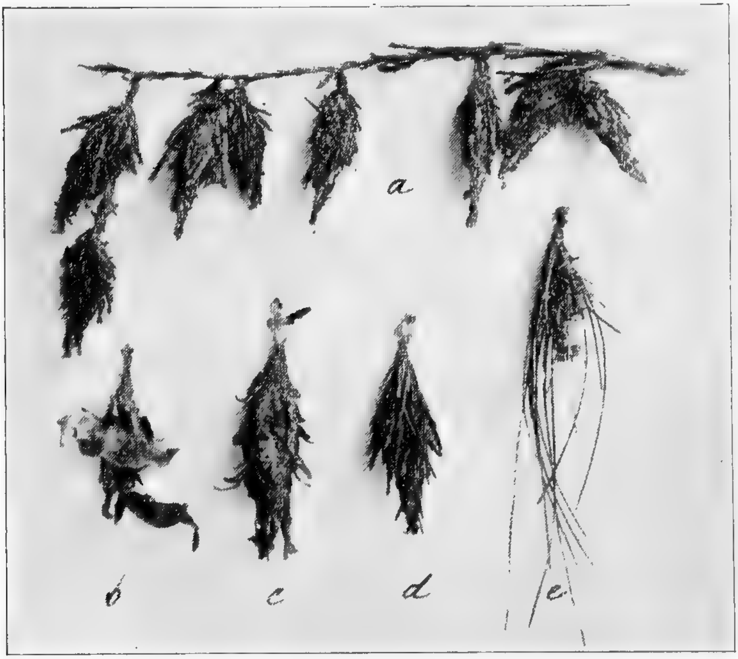


FIG. 8. The bag-worm. Showing the recently hatched worm engaged in constructing its case. (From Division of Entomology at Washington).

The adult male of the bag-worm is a very ordinary but rather fussy little moth, with black body and four clear wings with some black at the front and hind margins. When the wings are drawn out at the side they measure just about an inch from tip to tip of the front pair. The wings of the hind pair are much smaller. Its empty case may be known by the fact that it leaves the empty pupal skin partly protruding from the opening at the lower end.



FIG, 9. The bag-worm. *a*, cases fastened to twig of red cedar, as seen when the worms have changed to pupæ; *b*, *c*, *d*, *e*, bags taken from different trees. *b*, from maple; *c*, from arbor vitæ; *d*, from spruce; *e* from white pine. (From a photograph.)

LIFE-HISTORY FOR KENTUCKY.

The young bag-worms hatch from the eggs early in May, and before the end of June may become noticeable upon trees. They are especiallly fond of red cedar, and to a less extent of arbor vitæ, and may be found on such trees any season. When very abundant they often denude these trees badly, and will then appear upon deciduous trees in the neighborhood, ultimately when very abundant, as they were during the summer of 1893, occuring on most of our shade trees. No doubt they are carried from tree to tree by winds, as they may often be seen suspended from the branches by their silken threads. But dispersal by this means is uncertain and slow, and from the fact that the worms could be found on isolated deciduous trees last summer I incline to think they sometimes drop to the ground and creep from one tree to another. Burdened as they are with their cases they are not very active in migrating, and during ordinary seasons remain pretty closely confined to evergreens. During the past summer they were found to be common at Lexington on soft maple, elm, poplar, sycamore, black locust, red cedar, white pine, willow and linden. They occcurred throughout the State in injurious numbers. Mr. E. A. Trout, of Trimble County, wrote July 26 that they were stripping black locust trees of their leaves in his neighborhood, while in August Mr. Denny P. Smith of Cadiz wrote that they were killing red cedars in the western part of the State. About the 20th of August a small proportion of the sacks found on trees contain pupæ, and by September 5 most of the worms have changed. The winged male begins to emerge about the middle of September, the first of those kept by us at the Station having appeared September 16. On the 25th of last September they were observed to be emerging everywhere in large numbers, and the fully developed females were at this time found in their cases. During the early part of October the eggs are laid, the first being found October 8. By the middle of October most of the adults have disappeared,

REMEDIAL TREATMENT.

Like the fall web-worm this is a gnawing insect, and may be destroyed by spraying with London purple or Paris green. The important fact in its life-history is this: The worms which injure a given tree are largely in the egg state in cases attached to the twigs of this tree during the preceding winter. It sometimes involves considerable labor to do this, but for the evergreens (chiefly red cedar and arbor vitæ) from which this pest spreads it is not very difficult to remove and burn the cases. For other trees also this will generally prove the cheapest and most effective remedy, and it may be undertaken with the satisfaction of knowing that once the sacks are removed there is no immediate danger of the trees becoming infested to an injurious extent.

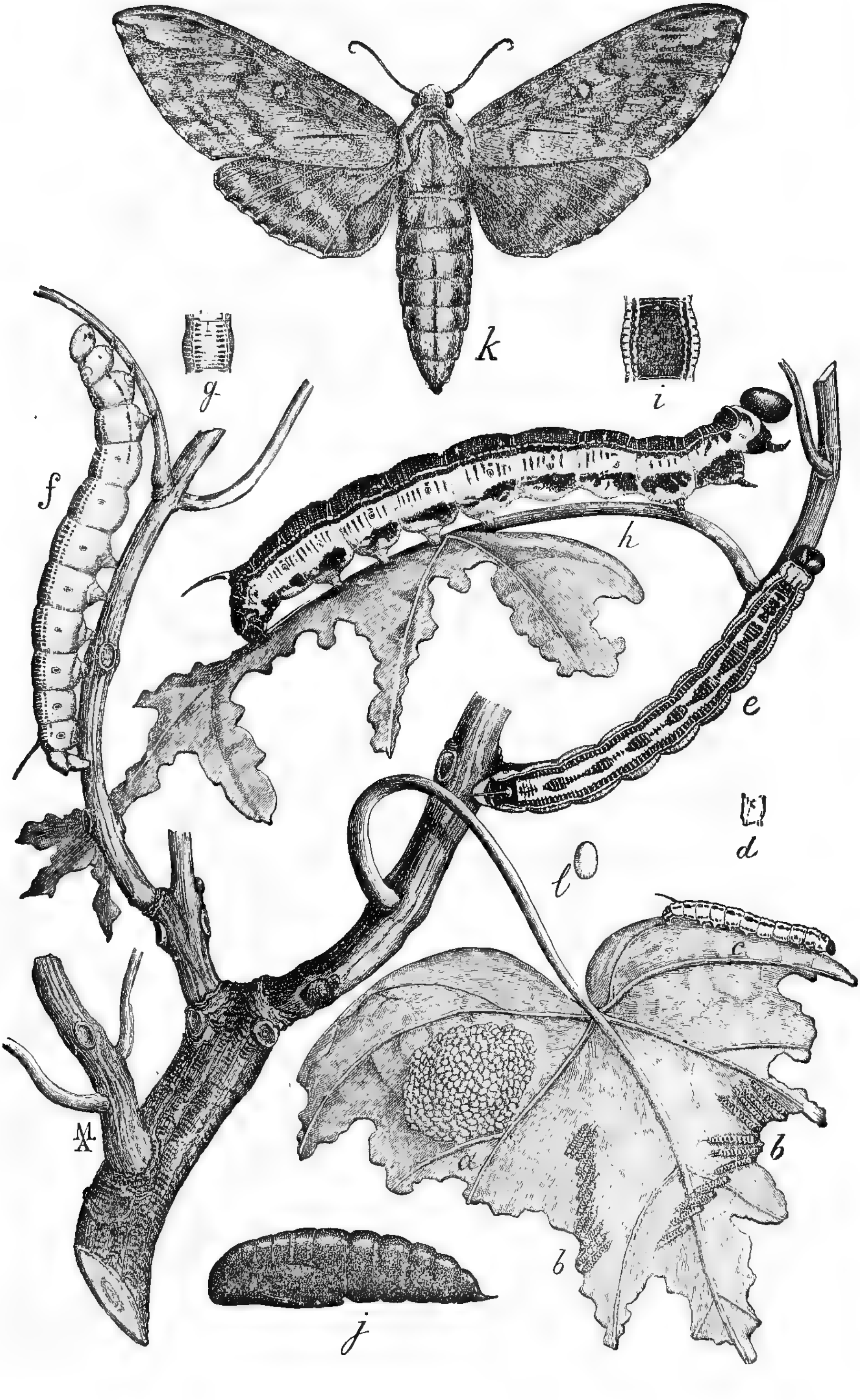
Several small four winged parasites attack the worms, but these emerge in the fall, as far as I have had an opportunity to observe, and hence there need be no hesitation in burning the cases during the winter.

The Catalpa Sphinx.

(*Sphinx catalpæ*).

FIG. 10. (On opposite page.) The catalpa sphinx. *a*, egg mass; *b*, *b*, young larvæ soon after hatching; *c*, young larva; *d*, view of one of its divisions enlarged; *e*, *f*, *h*, larvæ, the last fully grown; *g*, *i*, views of divisions of body; *j*, pupa; pupa; *k*, adult moth. (From Marx.)

During the summer of 1893 scattered catalpa trees in Eastern Kentucky were stripped of most of their leaves by a caterpillar resembling in shape the tobacco-worm. It is in fact a member of the same family as the latter. But it differs from the tobacco-eating worm in having a black head and a broad longitudinal stripe of velvety black occupying the middle of its back, a slender white line running parallel with each of its edges. The sides are sulphur-yellow dotted with black, while the under


k
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side is pale dull green. It does not attain to the size of the tobacco worm, fully grown examples measuring only 2.25–2.50 inches in length as against the 4.00 inches or more of the other.

Unlike the tobacco-worm it appears only locally and at irregular periods. But when it does come its voracity is so great and its numbers so large that infested trees are in the course of a week or two completely denuded of leaves.

During the past summer a few trees on the College grounds at Lexington were very badly injured, but other trees of the same species only a short distance from those attacked were untouched. The fact was the more noticeable because there were several broods of worms during the summer, and since the adult moth flies well there was no apparent reason why it should not have distributed its eggs on more of the trees. If this had been done, however, every tree on the grounds would have lost its leaves before fall, and hence we may suppose the habit of scattering over a wide area after emerging from the ground, instead of placing their eggs at once on trees about them, to be an arrangement for protecting the worms from their own destructiveness.

The worms leave the trees as suddenly as they appear, all going into the ground for pupation about the same time. The pupa closely resembles the brown objects with structure at one side like the handle of a pitcher which we find in gardens in spring. This latter is the pupa of the tobacco or tomato-worm. The pupa of the catalpa sphinx has the same general shape, but lacks the tongue-case. It varies in length from 1.28 to 1.56 inch. The color is bright fulvus (yellowish brown), with an obscure dark stripe along the middle of the back. The body tapers somewhat towards the extremities, terminating behind in a short spine, and in front being bluntly rounded. The surface is rather smooth and shining below, but above is minutely roughened, especially so on the head and thorax where it becomes opaque. On each side of the abdomen are three rather large slits on as many body divisions, and on each side near the front end is another similar opening. They resemble large hreathing pores, but cannot have to do with respiration because true pores (spiracles) occur on the segments of the body bearing the clefts.

The adult is one of the hawk-moths such as are seen about flowers of summer evenings. The catalpa moth is more retiring than others of its family, and has never been captured as far as I know about flower beds. I have not myself secured any examples except those carried through their changes in boxes. They are dull brownish gray in color with obscure lines and spots of black. The more noticeable marks on the wings are: A spot on the front margin of the fore wing about a third the distance from the base to the apex; from it a line extends obliquely across the wing and parallel and within the latter is another narrow line. The disk of the wing is uniformily brown excepting for a whitish dot encircled with black. The outer third of the fore wing has a number of zig-zag black lines extending across it, and a distinct black dash running from the apex obliquely inward. The hind wings show only two very obscure cross bands. The fringes are black, broken at intervals with white. The sides of the head and thorax are dark, brownish black. Above this the color is light gray, then come the black lines of the thorax separating the light gray from the brownish gray of the middle part of the thorax. The abdomen presents three distinct longitudinal lines of black, one median, the others at each side and consisting of a series of contiguous spots. Still farther down on each side is another very faint line likely to be overlooked. On the middle of the adbomen beneath are several small black dots. Large examples have a wing expanse of about 3 inches. The body measures about 1.25 inch in length.

LIFE-HISTORY.

The history of the worm for this region is as follows: The worms appear suddenly about the middle of June, hatching from eggs laid in a cluster on a leaf. On the 28th of June in 1893 those observed were nearly ready to leave the trees and all had done so and had changed to pupæ in the ground before July 10. The adults of this brood began to appear above ground July 17 and all were out before July 22, at which date one of the females in a box at the Station began to lay eggs for a second brood. On August 18, 1893, nearly grown worms of the second brood were obtained from trees at Lexington, and by August 21 these had gone into the ground for pupation. Four adult moths were obtained from these on September 13, '93.

Now either these moths hibernate and thus carry the species through the winter, or else they lay eggs for a third brood which passes the winter in the ground as pupæ. The latter method of hibernating seems the most probable in view of what we know of related worms, but my observations will not permit me to decide upon this point.

REMEDIAL TREATMENT.

Practically the question as to how these insects pass the winter is not of as much importance as in the case of some other injurious species. Spraying the leaves of infested trees with some of the well-known poisons mentioned above can be counted on as a safe remedy.

I found last summer that it was possible in the case of most catalpa trees to dislodge the nearly grown worms by jarring. By suddenly shaking a limb they could be made to drop like ripened fruit, and could then be quickly destroyed. In a few moments on one occasion I removed in this way every worm from a tree, to the number of not less than a hundred and fifty.

A CATALPA SPHINX PARASITE.

The worms are parasitized by a fly which places its eggs on their skins giving rise to grubs which bore into and live upon their tissues. The adult flies emerge after the catalpa sphinx has pupated in the ground.

The fly measures .31-.37 inch in length, is gray, with black markings, of which the more conspicuous are four narrow longitudinal lines on the thorax, and cross bands occupying the hind portion of the divisions of the abdomen. The face is silvery, the eyes reddish brown, the legs black, excepting the outside of the front thighs which are whitish. The whole body is protected by numerous strong black hairs these being especially well developed on the head above, and at the tip of the abdomen where they form a sort of brush. It does not seem to be common enough to help greatly in keeping the worms from mischief, but like other parasites may serve a useful purpose when its hosts become extraordinarily abundant. From more than a hundred worms kept at the Station during the summer of 1893 only four examples of the parasitic fly were obtained. Two of these emerged July 17, another on July 18, and the other, July 20.

The Walnut Caterpillar.

(*Datana integerrima*).

Walnut trees while not making the best of shade are frequently spared when growing about sites selected for dwellings. Their value in this situation is greatly diminished here in Kentucky by the attacks of a caterpillar on the leaves. It is no uncommon thing to see large trees 50–60 feet in height almost completely deprived of foliage in the latter part of summer by these caterpillars. In addition to destroying the leaves they make themselves very annoying by throwing down refuse and by overrunning walks and buildings in the neighborhood when they descend from the trees to go into the ground.

The caterpillars when grown are black, without evident markings, and are loosely clothed with soft whitish hairs. When they come down from the trees they measure about two inches in length. The young caterpillars are paler in color, and are distinctly striped with whitish. When they leave the trees they have the singular habit of collecting on the trunks near the base in large masses of a hundred or more individuals. At Lexington such masses have been observed as early as July 19, these probably representing an early brood, but the injury is at its worst during August, and the greater number of larvæ come from the trees during the last half of August and the first half of September. I have no record of adult moths observed between July 19 and September 1, but am disposed to think there are two broods every summer.

The pupa is formed in the ground under the trees, and that of the late brood remains here over winter, the moth emerging during the first half of June of the following spring.

The moth is reddish brown in color, with a patch of deeper brown on the thorax. The front wings, which have an expanse of from 1.80 to 2.30 inches, are crossed with five dark lines, the first being nearest the base, the second at about the middle of the wing, and the remaining three being close together on the outer half. The fourth line is fainter than the others and is very close to the fifth. The region between the first and second is darker than other parts of the surface and bears a black dot near the front edge of the wing. The moth is much like that of the next species, but its wings are less uniform in color and the cross lines are accompanied with rather wide but obscurely outlined pale bands.

Besides walnut the species is said to attack willow, honey-locust, thorn and apple. For several years I have had a walnut tree in my yard and among the many caterpillars and moths observed about it I have never seen an example of the apple-infesting species. Nor have I seen the present species on any other trees besides walnut and hickory.

REMEDIAL TREATMENT.

The remedies to be recommended for injury by this caterpillar are spraying the leaves with poisonous mixtures, and trapping the worms as they descend from the tree. The great height of walnut trees makes thorough spraying rather difficult unless one is well equipped for such work. The greater number of worms descend along the trunks of the trees during the night, and should be destroyed whenever found collecting on the trunks. To prevent the escape of those which do not collect in this way I would advise the construction of a wooden frame about the infested trees, similar to that which has been used in the East for the elm leaf-beetle.

A square frame could be fitted closely about the trunk near the base, and the corners covered or filled to keep the caterpillars from going down this way Then by tacking about its upper edges or along its outside a trough of tin to be filled with coal oil, their descent might be effectually prevented. Some of the worms drop to the ground from the leaves, hence the desirability of spraying the leaves when this is practicable.

Locust Leaf-Miners.

(*Lithocolletis robiniella, etc.*).

Locust trees in Kentucky seem to be peculiarly subject to the attacks of several leaf miners, the adults of which are small moths belonging to the same family as the common clothes moth. One or another species is to be found mining the leaves throughout the summer, from June to September, and often several may be found working together on the same tree. The moths themselves are rarely seen, because of their minute size. They place their lenticular eggs, usually one on a leaflet, and then disappear. But the flattened grubs hatching from these eggs bore into the leaf, eating away its substance and detaching at the same time the epidermis, thus producing blotches which at once attract attention. Towards fall one may see trees with most of the leaves rendered by these miners so brown that they give to the trees the appearance of having been killed. Examination of the leaves of locust trees at intervals during the summer will show the presence of four distinct species, three moths and one beetle, which may be recognized by the character of the mine. The grubs are so small as to be difficult of examination, except with a magnifier.

1. One of the most abundant of the moths plaçes its eggs on the leaves early in June, and its young make a large mine occupying much of the leaflets immediately above the midrib. These mines usually have extensions or lobes from the sides, so that their outline becomes finally very irregular. Several broods appear each season. The technical name of this miner is *Gracillaria robiniella.*

2. The second species, also a moth (*Lithocolletis robiniella*), proves common in the latter part of summer, my first record of its appearance being August 5. The majority of the mines of this species are on the under side of leaflets, and are of a pure white color. They may be at the margin of the leaflet or elsewhere, and the outline is generally not irregular. The grubs make for themselves small lenticular silken cocoons in the mines when ready to change, the moths emerging from them during

the latter part of August, possibly to place eggs for another brood.

3. The remaining moth (*Lithocolletis ostensackenella*) produces a yellow blotch-mine placed anywhere on the upper side of the leaflets, and at first narrow and tortuous, but finally enlarging suddenly and becoming more or less circular in outline. The mines begin to appear early in June (Observed by me first, June 11), are empty by the first of August, the moths having matured, and a second lot begins to become noticeable about August 24.

4. The fourth and last miner is, when adult, a small beetle (*Odontota scutellaris*), with somewhat flattened body measuring nearly .25 inch in length. It is black with the exception of the thorax and the sides of the wing-covers, these being tawny yellow. It is very injurious to black locust, and appears to attack apple leaves at times also. Mr. John W. Buck, of Midway, wrote me sometime ago enclosing specimens of the beetle and stating that it was ruining the leaves of his apple trees. The adults become common on the leaves of locust trees about May 22, and the peculiar egg-masses can be found by June 1. The masses consist of five or six discoid eggs placed one behind another, with their flattened surfaces in contact. The young grubs, which are not very different from those of the moths, cut through the side of the eggs next the leaf and bore down into the substance of the latter, all of those from an egg-mass living for a time in a single mine, but later scattering and making each a mine of its own. When removed from their mines they cut a slit in the leaf with their jaws and work their way into the leaf again very rapidly, the whole length of the body being concealed in less than an hour. By June 30 the grubs begin to change to pupæ, some leaving the mines for this purpose, and shortly afterward the beetles appear.

REMEDIAL TREATMENT.

It has been stated that hand picking can be made to check the injuries of the small beetle last mentioned, but to anyone who has witnessed its attacks in eastern Kentucky this will seem incredible. The larger part of the leaves of all the trees of a neighborhood may be occupied by mines made by one or more of the above insects. Since they are ordinarily concealed within the leaves it might seem that it would be impossible to reach them by spraying, but when it is remembered that this method has proved very satisfactory in dealing with the codling moth, and that the adults of the beetles feed to some extent on the leaves, it will not appear impracticable. I am inclined to believe it can be made to answer the purpose if it is supplemented by raking up and burning the fallen leaves in the fall of the year, so as to catch the species which spend the winter among them.

The Locust Leaf-Skeletonizer.

(*Gelechia pseudacaciella*).

This is another moth closely related with the three leaf miners mentioned above, which, associated with them, or alone, has a very injurious effect on the trees. The young of this is larger than the others, cylindrical, with striped body, and lives between the leaflets, which it fastens together with silk, and then gnaws away the surface of the leaf, exposing the skeleton. It has proved most injurious during August and September.

The same treatment is to be recommended as for the preceding.

The Locust Skipper.

(*Eudamus tityrus*).

The skipper of the black locust is a brown butterfly with wing expanse of a trifle less than two inches, and is so called because of its jerky flight. It may be seen about the trees in summer placing its eggs on the leaves, and is a common visitor to many kinds of flowers, being especially fond of nectar from the heads of red clover. The species may be known from some fifteen other skipping butterflies occurring in Kentucky by its superior size and by a large silvery white blotch on the under side of the hind wing. The front wings are marked by one large and several small blotches of brownish yellow. The mischief is done by the larva, a stout pale green worm, with large, globular, reddish brown head to which a comical expression is given by two round yellow spots, very likely to be mistaken for eyes.

The worms usually make their presence known by devouring the leaves. They feed largely at night and during the day are concealed in little shelters which they construct by stretching bands of silk across from one leaflet to another so as to draw them up and about their bodies. When a tree begins to lose its leaves one may by close looking find the culprits by these rolled leaves between which they lie. Several broods are reared each summer, but the eggs appear to be deposited at intervals during a considerable period of time, very young larvæ occurring on the same tree with worms nearly grown. The change to a quiescent pupa takes place within the rolled leaves which are lined with silk for the purpose.

The last brood does most of the mischief from which the locust suffers. Many of the larvæ are about one-fourth grown at this latitude on August 20 and change rapidly to pupæ about September 15, remaining in this condition over winter.

The injury is to be checked by spraying.

Poplar Defoliators.

(*Icthyura inclusa*).

Several caterpillars and leaf-miners mar the poplar trees planted in Kentucky, of which perhaps the most destructive is the above. When actively injurious it is a worm, or caterpillar, reaching a length of about one inch, and may be known by the following characters: Head, jointed legs, a plate at hind extremity, and two double tubercles on the back, black. Four longitudinal yellow lines along the middle of back. Each side with faint yellow lines and two series of black dots.

The caterpillars are found during the day in leaves which they have rolled together and lined with silk, the petioles being fastened to the twigs with silk. Young Lombardy poplars are often seen with but little in the way of leaves besides those occupied by the caterpillars. They appear in June and again in August, hatching from eggs of a pale lilac color placed in a single layer of from 114–134, on the under side of the leaf. The eggs (.02 inch in diameter) appear to be spherical but really are only about two-thirds of a sphere, the side attached to the leaf being fattened. The eggs are laid by an obscurely marked gray moth with wing expanse of about 1.12 inch.

Immediately after hatching the worms are pale green with numerous black spots, the double tubercles being just visible. They live in a company on the upper side of the leaf, building over themselves a tent-like web, and gnawing away the upper layer of leaf substance so as to expose the skeleton, eventually the leaf is drawn together so as to completely enclose them, but with openings through which they can pass in and out when feeding. Other species which also fold the leaves are sometimes associated with this species on the same tree. Since all

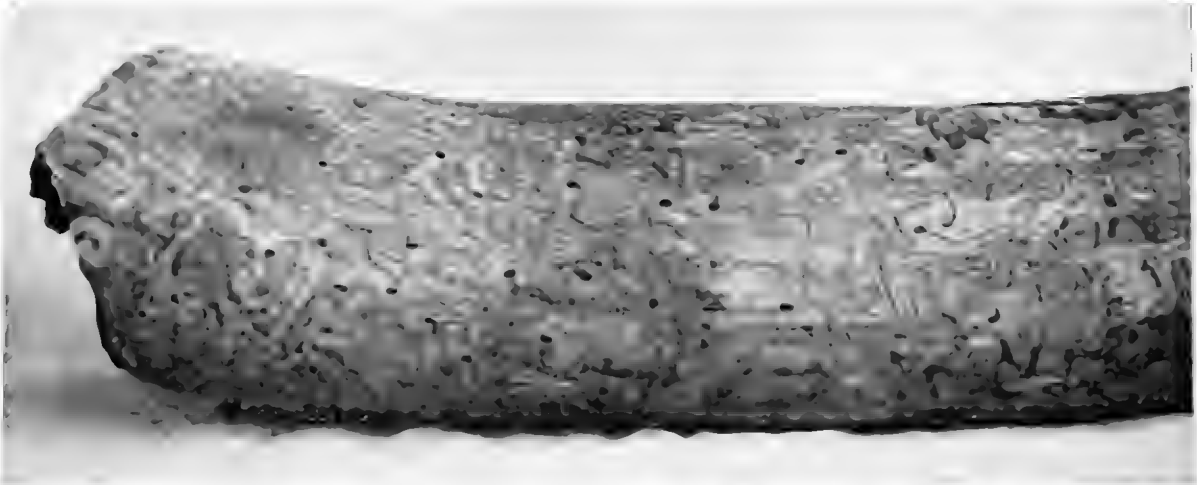

FIG. 11 Part of a Frankfort elm with bark removed so as to show the work of the elm borers. (From a photograph.)

injure the leaves in the same way, viz. by gnawing, it is not necessary to give a separate account of them at present.

They can be destroyed by spraying with Paris green.

The Elm Borer.

(*Saperda tridentata*).

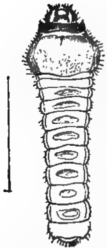

Fig. 12 The elm borer grub. The line at the left of figure shows the natural size.

In the latter part of June, 1892, my attention was called to a diseased condition of elm trees about the streets of Frankfort, the nature of which was not apparent, though it was supposed to be due to the attacks of insects. On June 27 I made a visit to Frankfort for the purpose of examining the trees, and found that some valuable elms were dying, and that several others were already dead. The affected trees were among the largest and finest in the city. All those examined were American elms (*Ulmus americana*). The trouble was said to be new to the locality, but appeared to be making rapid headway. Examination of the dead and dying trees showed that their condition was not due to injury by leaf-eating insects, for the foliage remained untouched. An examination of affected trees which still retained many green leaves showed that the bark was unsound in places near the base of the trunk, but most of the insects under such bark were common species known to feed on dead wood everywhere. From burrows under some of this bark, however, a borer was obtained which belongs to the species the name of which heads this paragraph. The number present did not seem to me sufficient to account for the death of the trees. In fact, on one of those almost dead, the inner bark, though discolored, was intact, and no trace of insects could be found about it. Such insects, however, may begin their attack on the branches and upper parts of the trunk, and an examination of these parts could not be made conveniently without cutting down the trees. When this was done in the fall I was enabled through the kindness of the State Commissioner of Agriculture and his assistants to examine the trees again. On the 10th of September my assistant, Mr. Terrill, went to Frankfort and brought back with him a portion of one of the trees for more careful examination at the Station. The elm borer was then found to be abundant under the bark, always in the grub state. The inner bark of the greater part of the trunk was mined and eaten so that it could be detached in large pieces. The portion brought to Lexington was from one of the larger branches, and was cut out near the trunk. Several wood-boring grubs were found at work on it, but by far the larger number were the species which had been found mining the bark earlier in the season. It was therefore evident that the injury was done in part at least by the elm-borer. The decline of the trees may have been due primarily to something else, such as exhaustion of nourishing matter in the soil. A starved tree is always the prey of injurious insects and fungi, somewhat as a feeble man is more subject to disease than a strong and vigorous one, but there can be no question as to the activity of these insects in destroying the trees upon which, from whatever cause, they once secured at foothold.

The insect is not a new one in this part of the world It was known to the authorities of eastern cities many years ago as an enemy of the elm trees planted for shade along thoroughfares. Writing of his experience with it among trees on the Boston Common in 1847, Harris says: "The trees were found to have suffered terribly from the ravages of these insects. Several of them had already been cut down, as past recovery; others were in a dying state, and nearly all of them were more or less affected with disease or premature decay. Their bark was perforated, to the height of thirty feet from the ground, with numerous holes, through which insects had escaped; and large pieces had become so loose, by the undermining of the grubs, as to yield to slight efforts, and come off in flakes."

Somewhat later Dr. Asa Fitch observed the same insect about diseased elms in New York. The species attacked in this case was the slippery elm (*Ulmus fulva*) and he states that whenever portions of the bark of this tree has been stripped off for medicinal purposes "the remaining bark immediately becomes filled with these worms, by which all its inner layers are consumed in a few months and changed to worm-dust."

More recently still an outbreak of the pest occurred in Illinois where I had an opportunity to observe it. Its work in this State was not confined to large trees, young ones twenty feet or less in height being also attacked- At the time of the outbreak Prof. Forbes the, State Entomologist wrote: "The difficulty with the trees commonly commences to declare itself from the middle of summer to autumn, when the leaves, first upon the terminal twigs and then upon the larger branches, are seen to stop their growth, change their color and ultimately to fall." The first attack was sometimes made on the upper branches these being killed while the remainder continued to put forth new leaves until they were in vaded.

The grub which mines the bark measures when fully-grown and extended about one inch in length, is cylindrical in general shape, but becomes somewhat enlarged and flattened at the front end, like the round-headed appletree borer The head is immersed in the succeeding division of the body and hence seems smaller than it really is. It is of a dark brown color and is provided with strong black jaws, usually more or less concealed by a membranous upper lip. The next division of the body is largest and widest, measuring about twice as wide as long; it is covered above with a rather firm, yellowish brown crust forming a sort of shield, and bounded at each side by a short groove. The succeeding divisions becoming rapidly narrower to the fourth from which the diameter changes but little to the last but one. The terminal division of the thirteen composing the body is small and conical. The grub has no legs.

The winter is passed in the grub state, but the next spring the pupa stage is assumed in the burrows. Those obtained at Frankfort are one half inch long, rather slender, the abdomen being somewhat produced but terminating bluntly. Limbs and wing-pads folded againt the body as usual in such pupæ. The antennæ extend around the femora of the two first pairs of legs, then turn forward so that the tips lie above the free mouth parts. On the head and thorax are a number of short black hairs arranged symmetrically, of which a series of four or five below the antenna of each side and others along the front division of the thorax are conspicuous. Divissions of the thorax with a median longitudinal channel above. Abdomen distinctly segmented, margined, each divisionwith tubercles with small minute spines projecting backwards. Tip of abdomen with a number of short hairs on each side. This stage lasts but a short time, when the final moult of the kin takes place and the adult beetle comes forth to lay eggs on the bark of trees for a fresh lot of grubs.

The beetle is a small slender insect, rather obscure in its colors, and so shy and retiring of habit that it is not often seen. It measures about 0.50 inch in length. Its color is brown with a grayish cast. It is marked with several black dots on the thorax and wing covers, and on the latter at each side is a margininal line of dull red from which are given off three branches which project obliquely backward. The latter markings give the species its technical name *tridentata.*

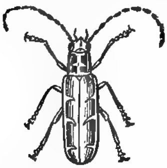

FIG. 13. The adult of the elm borer.

Quite a number of parasites, small four-winged flies, were obtained from wood from a diseased Frankfort elm, but since there were three other borers besides the one described above, at work on the wood it is not certain which species they were preying upon. The presumption is from the greater numbers in which the elm borer occurred that they come from it, and there is reason to hope that these friends of ours will greatly increase.

The adult beetles emerged at the Station during May and the first half of June. A single living example was taken from the boxes which our infested wood was kept on July 21, hence the beetles are probably abroad during some portion of July also.

REMEDIAL TREATMENT.

It will be seen from the statements already made that the borers are in the bark of trees during the fall and winter months, and it is plain that if affected trees could be cut down and burned at this time large numbers of the insects would be destroyed. This practice is to be be recommended for all trees which are plainly past saving. Burning during the spring and early summer could not serve a useful purpose because the beetles are out of the bark during this part of the year.

To defend trees from attack it may be suggested that the trunks and if possible the larger branches be coated with whitewash to which Paris green has been added in the proportion of ¼ pound to ten gallons of the wash. This poison is known to have a good effect in saving vegetation from attacks of insects by killing the young when they begin to bore into the tissues. Such a wash should be applied early in the spring before the beetles emerge, and should be renewed from time to time as long as there is danger of beetles being about, i. e. until the middle of July.

A good many years ago a French authority on forestry recommended the scraping and cutting away of the bark of trees attacked by borers as one of the most satisfactory remedies known to him. His idea was that this treatment encouraged the flow of sap to the scored bark so that the grubs were unable to mine it. It is well known that trees do defend themselves under some circumstances by filling up the burrows of insects as fast as these are made, and on some fruit trees one may find scores of burrows thus started and afterwards abandoned because of a gummy exudation which fills them. The experiments of the Frenchman, M. Robert, were made chiefly on elms, but with reference to beetles belonging to a different family from that of the American elm borer. Both bore into the inner bark and sap wood however, and it is probable therefore that the treatment he recomends will serve as well for our elms. He began by cutting out long strips of bark about 2-2.50 inches wide, extending from the ground to the branches. A new growth of bark was at once formed here which projected as a longitudinal ridge in which the sap circulated so vigorously, that the grubs in the immediate neighborhood were destroyed, and the tree itself showed an increase in general vigor. His next experiment was to remove from infested trees all the outer bark of the trunk usually styled the corky layer. It was found that the grubs in the inner bark quickly perished, either from the increased flow of sap, or from more complete exposure to the action of the sun. He claimed that this treatment stimulated the trees to renewed growth, that it improved their general condition, and that the new bark which replaces that which is removed is so smooth and thin that the beetles will not resort to it to deposit their eggs. The treatment, it is held, does no injury to the trees. M. Robert treated at one time over 2,000 trees along the boulevards and public roads of France with marked success. The same treatment serves, it is said, to invigorate apple trees which have ceased to bear, and has long been employed by fruit growers in Normandy.

Pine Bark-Beetles.

(*Tomicus calligraphus, etc*).

Pine trees in cultivation sometimes suffer from the minings of small stout bodied grubs which destroy the inner bark in much the same manner as the elm borer. Several different species of the same family (Scolytidæ) are often concerned in this work of destruction, but the one found abundantly on pines in this vicinity is the species named above.

The adult beetle is a small compact, cylindrical, brown object about 0.20 inch long, with short legs, and is to be known from beetles of other kinds by a singular excavation at the extremity of its body with toothed edges. It looks as if it had been mutilated by having the hind part of the wing covers gouged out. These beetles bore into the bark of trees making a channel of some length which after the inner bark is reached, is made parallel with the surface. The eggs are placed at intervals along this channel, and the grubs hatching from these push into the adjacent bark, so that it becomes eventually completely destroyed by them.

The adults appear very early in the spring, being observed by us to be abundant under the bark of an Austrian pine at Lexington, February 29. At this date no larvæ or pupæ could be found, though the pupal skins were common in the burrows, showing that the beetles had recently matured. Beetles of this brood place their eggs in burrows under the bark during April and May, and then disappear. The grubs hatching from these mature during the summer and place eggs for another brood, which is in turn matured in the fall and winter months. The beetles found by us in February belonged to this brood, and were evidently only waiting for mild weather when they would have escaped and deposited their eggs.

I am disposed to think that this beetle attacks trees only when their vitality is already low, from the effects of drought, unfavorable situation, or the attacks of other pests. However this may be, it sometimes completes the destruction of valuable trees, suffering from what would otherwise have been only a temporary weakness.

Trees in a dying condition from attacks of such borers should be promptly cut down and burned, care being taken to destroy all the bark and larger branches. Borers of this sort have been known to be desseminated among trees of a neighborhood from the lumber and logs about saw mills. Dead and dying trees infested with borers are even more to be feared as centers of dissemination of pests. They can be burned to best advantage in winter, since the beetles are dormant at this season, under the bark. During spring and in mid-summer they are abroad finding places to deposit their eggs, and hence burning at these times could not be expected to do so much good. Coating trees liable to attack with whitewash to which some Paris green has been added is a treatment I have sometimes recommended as a means of deterring the beetles from boring into the bark to place their eggs. To be effective such treatment should be employed very early in spring before the beetles leave their winter quarters, and the applications should be renewed from time to time during the summer.

Removing the outer bark to expose the grubs and stimulate the activities of the trees, as suggested in treating the elm-borer, may be found effective for the pine bark beetles also, as M. Robert's experiments were made with reference to checking the injuries of a closely related insect, belonging to the same family.

The Maple Bark-Louse.

(*Palvinaria innumerabilis*).

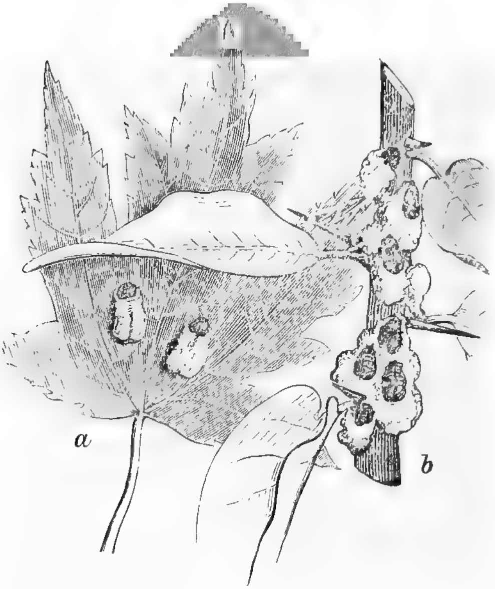

Fig. 14. Maple tree bark-louse. *a*, on the leaf; *b*, crowded together on a twig. (From Riley).

This is the insect that may be seen forming white cottony tufts on the twigs of maple trees along our streets in early spring. It is one of the scale-insects, and does its mischief by puncturing the leaves and abstracting the sap of the trees. The species has already been treated in Bulletin 40 of the Station, to which those interested in the pest are referred. It is quite uniformly distributed among maple trees in Kentucky, and will bear watching.

II. AN EXPERIMENT ON PLUM ROT.

BY H. GARMAN.

Several plum trees standing near the house on the Experiment Farm have always been badly affected with the brown rot, due to the fungus parasite, known as *Monilia fructigena.* Last spring it was decided to treat one of these trees with Bordeaux mixture, leaving another standing beside it as a check. The former was sprayed on June 9, 1893, with Bordeaux mixture, about 2½ gallons being applied to the leaves and young fruit with a knapsack sprayer. The mixture was prepared by the formula employed for the apple experiments of 1892, and reported in Bulletin 44.

On July 5 the tree was sprayed again, about the same quantity of the mixture being applied.

The season was very unfavorable for fruit of all sorts, and neither the sprayed nor the check tree bore as full crops of fruit as usual. As far as it goes, however, the result is in favor of spraying. Some rotting fruit was observed at the time of picking on both trees, and a good

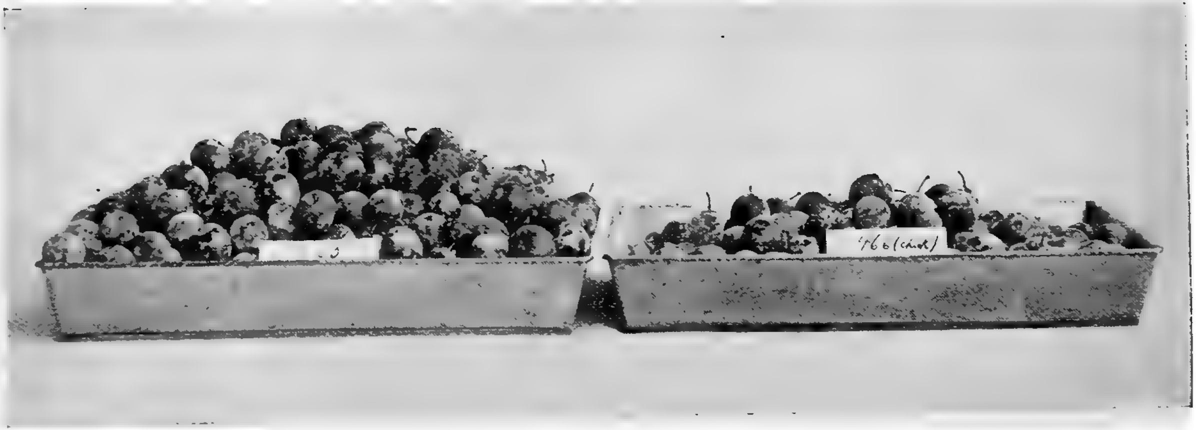

Fig. 15. 465, showing plums taken Aug. 22 from sprayed tree; 466, showing plums taken from check tree.

many plums rotted and fell from both during the summer. On August 22 the plums were removed.

From the sprayed tree (No. 465) I took 477 plums, weighing 11½ pounds. These averaged a little smaller than those from the check tree, and the skins of some showed a peculiar roughness due either to a caustic action of the mixture, or else is simply a peculiarity of the tree. As the fruit of the trees have not before been compared, it is not safe to decide about this. I have never witnessed any similar effect from spraying grapes and apples, though it may prove that plums are more sensitive to the copper and lime.

The unsprayed check tree (No. 466) yielded 254 plums, weighing 6 pounds and ½ ounce.

The difference in favor of spraying is thus about 5½ pounds in the weight of fruit. Or we may say the spraying increased the yield about 48 per cent.

THE MORE IMPORTANT INSECTS AFFECTING OHIO SHADE TREES.

OHIO
Agricultural Experiment Station.

WOOSTER, OHIO, U. S. A., JUNE, 1908.

BULLETIN 194.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 194. JUNE, 1908.

THE MORE IMPORTANT INSECTS AFFECTING OHIO SHADE TREES.

BY J. S. HOUSER.

INTRODUCTION.

With the rapid decrease in the forest acreage of the country we are learning to appreciate trees, both for their beauty and for their value as an economic factor in our welfare; hence, the problem of their preservation is coming to mean more and more to us. Generally speaking, this decrease in the number of trees has been accompanied by an increase of the insect foes that prey upon them, both as regards numbers of species and individuals of a given species. Further, this band of depredators seems to be getting in its work more effectively in the city districts than in those more rurally situated. This publication, therefore, from the very nature of things, will be of greatest value to the city householder, but may be applied to the needs of all.

INSECT CONTROL A NECESSITY IN CITIES.

For several reasons the employment of artificial measures against shade tree insects is more nearly a necessity under conditions that exist in the cities and towns than under those found in the rural districts.

Absence of insect-eating birds. The absence of many of the insectivorous birds partially explains the abundance of insect life in the cities. Since the advent of the English sparrow—a bird which is not a pronounced insect eater—many of the birds that previously nested in the cities have been driven to more remote districts.

City trees unhealthy.

The city tree under the most favorable conditions must keep up a continual fight for existence. Impure, smoke-laden atmosphere; poorly watered and badly ventilated root system; the careless, thoughtless mutilation by teamsters and passers-by, all tend to weaken it. If in this weakened condition it becomes the subject of attack, it is poorly fitted to withstand the burden and, unless assisted, stands a poor show to win out in its fight for existence.

INSECT CONTROL DIFFICULT IN CITIES.

Individual work of householders impracticable.

The application of insecticidal measures is a difficult task under most city conditions, especially so if the various householders attempt the operation individually. It is usually the case that a few trees only are located in each yard, and frequently these trees are tall, thus requiring a strong, expensive spraying apparatus for treating them properly. Besides the sprayer the service of two men is required, at least one of whom should have a knowledge of machinery and the preparation of insecticides to insure best results. It is only in the case of large lawns that it would be practicable for private individuals to own and operate spraying outfits.

However, in a few instances, designated in the description of the various shade tree pests following, it is possible for the householder to furnish effective assistance, and to do so with small expenditure of time and money.

A municipal tree-treating department desirable.

The more desirable and practicable arrangement is for the city to support a tree spraying department, operated by competent, experienced men, whose business it is to look after the public trees and who are prepared to do spraying on private grounds for a reasonable charge. Such departments are already in existence or are under way of organization in some of our principal cities, the department at Cleveland being the most complete in this state.

CORRECT PLANTING THE FIRST STEP TOWARD INSECT CONTROL.

From the standpoint of the future control of insect pests, two things should be considered in the planting of a shade tree; the species of tree and the location of planting.

Some trees more susceptible to insect attack than others.

All kinds of shade trees are not equally susceptible to insect attack, some being almost immune, others so highly susceptible to attack from one or two species that it is impossible to grow them, while still others are the prey of a whole host of depredators.

Dr. E. P. Felt, in his most excellent work on "The Insects Affecting Park and Woodland Trees," has tabulated the more common trees of New York state with relation to their liability to insect attack. As Ohio conditions do not vary to any great extent from those found in New York state, the classification arranged for New York holds good in the main here. Dr. Felt's rating, with a few alterations that will be designated later, is as follows: "The figure 3 has been placed opposite trees which are practically immune from insect injury; 2.5 indicates some damage. Trees having one somewhat serious enemy are rated at 2 and those having at least one notorious insect pest at 1.5. Greater likelihood of injuries is indicated by 1 and still more by .5. The species are arranged according to the comparative injury as follows:

Tulip tree	3
*Tree of heaven	3
Gingko	3
Red oak	2.5
Scarlet oak	2.5
Oriental plane tree	2.5
American plane tree	2.5
Sycamore maple	2
Sugar maple	2
White oak	2
Burr oak	2
Red maple	2
Honey locust	2
Catalpa	2
European linden	1.5
American linden	1.5
Horse chestnut	1.5
Soft or silver maple	1.5
American elm	1.5
*Hackberry	1.5
European elm	1
Scotch elm	1
Cottonwood	.5
Balm of Gilead	.5
Yellow locust	.5

*Those that are starred have been seen only in parks or in such small numbers that the rating can be regarded as provisional only."

The above arrangement differs from that of Dr. Felt's list in the position of catalpa, rated by him as 3 and here rated as 2 on account of it's being subject to attack from the catalpa sphinx in the southern sections of the state and rather generally to the action of the catalpa diplosis (or a closely allied species) working in the tender, growing tips. Also the hackberry and elm are rated .5 higher because of the fact that the elm leaf-beetle is not well established in this state.

Plant mixed varieties.

Another general principle of correct planting, as brought out by Dr. Felt, is the undesirability of planting clumps or rows of a single species. It may easily be seen that an insect on the hunt for its favorite food plant is much more likely to locate a collection of trees than single individuals scattered here and there. Further, that a pest is more easily disseminated when once it becomes established on one of a number of trees of the same variety growing close together, than if the trees were at least alternated with other kinds.

Avoid poor environment at planting time.

It is an admitted fact that insects prefer the weaker to the stronger plant, and when we consider how much more easily a healthy, vigorous tree withstands insect attack than does its weaker neighbor, it is self-evident that, if for no reason other than the future control of insects, we should attempt to grow strong trees. Much can be accomplished toward this end by not planting in unfavorable immediate surroundings, such as over or near a gas main, thus running the risk of having the tree poisoned by escaping gas; nor directly under high-tension electric wires, the injurious burning effects of which are well known; nor too near the street, where the trunks are subject to injury; nor in soil deficient in plant food; nor in a half dozen or more additional situations that might be named.

Plant to make insect warfare possible.

Tall growing species subject to insect attack should not be planted close beside buildings, thus making it impossible to spray them properly without covering the side of the building with the spraying mixture. This is one of the great difficulties experienced by a city spraying department. Householders object seriously—and justly too—to the disagreeable mixtures. To illustrate the necessity for exercising this precaution take, for instance, the applying of the lime-sulfur wash, a mixture used quite extensively as a scale destroyer. This mixture when sprayed upon a painted surface combines chemically with the paint, causing some shades to discolor. It is absolutely impossible to spray a tree located beside a building without some of the mixture being misplaced.

COMMONLY INJURIOUS SPECIES.

It is the author's intention in his treatment of the individual shade tree pests to deal with each species as briefly as possible, but at the same time to afford a working knowledge for operations against it. To this end the description of the various insects will be confined to pointing out the characteristics most useful in differentiation, and only such phases of their life histories will be dwelt upon as bear directly upon our understanding of the methods of control suggested. No attempt is made to list all of the insects that may be found injuring ornamentals or forest plantings within the borders of the state, but only those species are considered which are at present doing damage or those that may likely be introduced within the near future. For more complete information, no better source may be found than Memoir 8, New York State Museum, entitled "Insects Affecting Park and Woodland Trees" by Dr. E. P. Felt.

The observations and practical spraying experience herein recorded, in addition to the information compiled from the writings of others, are mainly the result of work done by the Ohio Experiment Station, in co-operation with the Department of Forestry of the City of Cleveland.

SCALE INSECTS.

Scale insects are among the most formidable of the pests from which the shade trees must be protected. On account of small size and protective coloration they frequently escape detection by the untrained eye until they have secured such a strong foothold that the host is permanently injured. Further, in addition to the advantage they possess by reason of the insidious nature of their attack, some are extremely resistant to remedial measures, among these being some of our most common species, such as oyster shell bark-louse, terrapin scale of the maple, etc.

The majority of the species remain fixed after the scale covering is formed. The spreading is effected by the young as they crawl about seeking a suitable place to begin feeding; as they are carried short distances by spider webs or winds; or possibly longer distances upon the feet and feathers of birds. This motile period in the history is of short duration, usually not longer than two or three days.

Insects of this order obtain their food by inserting their sharp, hair-like beaks into the tissues of the plant and drawing out the sap, hence applications of poisons are ineffective, and for all practical purposes it may be said that control methods are confined to spraying with contact insecticides during one or both of two seasons, the latter depending upon the species. Some scales are more easily destroyed by the action of a strong spray, used during the winter months, while others are susceptible to treatment with a weak spray applied during the summer months when the brood of young is appearing. The last named method, however, is useful only when the entire brood of young appear within a few days, and when the host is foliated sparsely enough to permit the spray to reach all parts of the plant.

The oyster-shell bark louse, Lepidosaphes ulmi.

In appearance this scale is dark brown in color, shaped like an oyster shell, and is about one-eighth inch in length. (Plate 1, Figs. 1, 2 and 3.) The winter is passed in the egg stage under the protection of the covering scale, the large quantity of whitish eggs being quite easily detected if the covering is removed. The eggs hatch during the latter part of May or early June, at which time the tiny, yellowish, mite-like scale insects may be located by the unaided eye, as they crawl about seeking a suitable place to begin feeding.

A number of plants are quite susceptible to this scale, the most common for Ohio being Carolina and Lombardy poplar, willow, horse chestnut, ash, sassafras, and red-twigged dogwood. The poplars are undoubtedly the most susceptible of all, and so injurious in fact is this scale to these trees that the authorities in Cleveland have stopped the planting of them, and wherever practicable are replacing growing trees with more desirable kinds.

Spraying during the early spring with the lime-sulfur wash, or during the hatching period with kerosene emulsion or whale oil soap solution, is the remedy usually employed against this pest. However, for extensive spraying operations, the two latter materials are hardly practicable, as in order to be effective they must be applied during the interval between the hatching of the scale insect and the completion of the first scale covering. This allows a few days only and therefore is prohibitive of work on a large scale.

The lime-sulphur wash is undoubtedly the best of the control methods to be used against this scale, but in the author's experience it has proven somewhat of a disappointment. From observations made upon hundreds of trees and shrubs, sprayed with a mixture made by experienced men and applied thoroughly, it is apparent that only when conditions are the most favorable are the results following its use satisfactory.. A slight dampness, such as light fog, at the time of application; a somewhat weakened spraying mixture; an extra case of infection where several scales are piled upon one another; a temperature below 32 degrees; any of these unfavorable conditions is sufficient to give poor results.

In spraying trees that are deeply incrusted with the scale, the mixture cannot be forced to penetrate underneath the outer layers and frequently many escape, to multiply the ensuing year.

Sassafras and soft maple, both well infested with this species, were carefully sprayed under favorable conditions during the spring of 1907, with scalecide and limoid. This scalecide was used in a 5 percent solution, and the limoid was prepared after the following formula: Limoid, 30 lbs., kerosene, 7½ gal., water to make 50 gallons. In every instance the scale increased abundantly during the ensuing season, indicating that little benefit had resulted from the treatment.

Because of the power often possessed to withstand the action of the most practicable of the stronger scale insecticides as a winter treatment, and of the the impossibility of doing extensive work during the summer period, the writer is almost ready to place the oyster shell on a par for destructiveness with the San Jose species, when it occurs under city conditions.

The San Jose Scale, Aspidiotus perniciosus Comst. This species is almost well enough distributed and well enough known to render a description unnecessary. However, it may be stated briefly that the individual scales are very flatly conelike, with a whitish nipple at the apex; the remainder of the scale is gray or blackish and the whole is about the size of a pinhead. When occurring in large numbers on a branch it gives it a gray ashy, flaky appearance. Additional distinguishing features are that when a tree becomes badly infested, pressure upon the limbs with a knife blade or similar flat instrument causes a yellowish oily liquid to appear. Following infestation the tree assumes a sickly appearance and ultimately dies if uncared for. The length of the period between infestation and fatality depends of course upon the natural hardiness and the resources of the host. Some trees and shrubs may withstand the burden of attack a considerable number of years while others, less hardy, as the peach, may succumb in as few as three years. According to Dr. W. E. Britton, State Entomologist of Connecticut, a little over one-third of the trees, shrubs, and vines grown for fruit and ornamental purposes are subject to serious attack from this species, while an additional third are occasionally or rarely infested. The more common of the plants suffering seriously are as follows: juneberry, hawthorn, privet, poplar, Prunus spp., currant, apple, rose, willow, ash, lilac, osage orange and elm.

The scale is well distributed throughout the State, there being very few counties only from which it is not reported. It is rapidly gaining headway each year, notably in the cities and towns, where as yet comparatively little systematic work has been attempted to hold it in check.

In many parts of the country and particularly in the orcharding districts annual spraying is being performed. Where such is the case and thorough work is done the advance of the pest is being checked and the damage reduced to a scarcely perceptible amount.

A winter application of the lime-sulfur wash is the safest, most effective and cheapest remedy for this pest. However, by way of modification of the statement concerning the cost of the spray, it should be said that this holds true only where the wash may be purchased at a rate affording no more than a reasonable profit to the maker, or where the area to be treated is sufficiently large to warrant the expense of setting up the boiling plant. Where it is impossible to purchase the wash or where it is impracticable to arrange a private plant for preparing it, then some of the commercial insecticides may be resorted to. Among washes of this class the Experiment Station has tried during the past two or three years, the one known as Scalecide has given the best results. This material is a patent so-called soluble oil, in other words an oil emulsified so that when water is added the two combine, resulting in a milk-white, oily spray. This material is not excessively expensive and serves most excellently the purposes of the householder who has a small area to be treated, and who has not access to the public sprayer or cannot hire the work done.

The Scurfy Bark Louse, Chionaspis furfura Fitch.

This insect appears in the adult stage as flat white specks upon the bark or fruit of the host. The female is about 1-10 inch in diameter and shaped after the outline of a pear, while the male is about one-third as large and more elongated. (Plate 1, Figs. 4 and 5.) With both sexes there is a yellow pellicle at the tip end of the scale. The winter is passed in the egg stage under the protecting mother scale, hatching occurring during the latter part of May or in early June.

Some closely allied species occur in great numbers at times on park trees and shrubs, but for the most part they have life histories that are similar to the common species and in general the same remedies will apply. The red-twig dogwood, willows and some of the rosaceae are particularly subject to such infestation.

The lime-sulfur wash applied during the winter is effective, as are also contact sprays applied at hatching time. However the same difficulty arises here that is encountered in connection with summer applications against the oyster shell bark louse, *i. e.*: the brood appears *en masse* and the time for effective work is as a result very brief.

The Putnam Scale, Aspidiotus ancylus Putnam.

On account of similarity in general form this species is frequently mistaken for the San Jose Scale, especially when the infestation is slight and the scales immature. The superficial distinguishing features however are as follows: the scale is slightly darker in coloration; the nipple reddish; the spread less rapid; the injury less severe, and lastly the young exhibit a stronger tendency to settle about the mother, resulting in a somewhat irregular infestation.

This insect occurs more commonly in the towns than in the country, and the trees most generally attacked are hard maple and linden. The maples in the parks and upon the streets in Cleveland suffer severely from this pest.

The lime-sulfur is effective against this pest. Applications of limoid and scalecide gave fair returns.

The Rose Scale.
Aulacaspis rosae Bouche

This species resembles the scurfy bark louse, though the general appearance of the infestation as a rule is of a whiter, fluffier nature. (Plate 2, Fig. 1.) The life history is practically the same as that of the scurfy scale, and the winter applications of the lime-sulfur wash are effective. Scalecide in 5 percent solution was not successful.

Roses, blackberries and raspberries are most commonly attacked. *Rosa rugosa* is more severely attacked than other roses, but even with this variety, the writer has observed very few instances where the plants were killed.

The Elm Scurfy Scale.
Chionaspis Americana Johns.

This species occurs upon the elms and the lindens. It resembles very closely the scurfy bark louse, in fact it is quite likely that for many years it was confused with this insect. The life history is the same. In the writer's observation, however, the elm scurfy scale is not so evenly distributed over the host plant as is the scurfy, the lower side of the branches being more subject to infestation.

Lindens moderately infested with this scale were sprayed with lime-sulfur, April, 1907. Observations made during the ensuing season indicated that the results of the application were all that could be desired. In the vicinity of the lime-sulfur sprayed trees, other lindens were sprayed with 5 percent scalecide. Little good seemed to result from this treatment, as the scale developed in abundant quantities during the following season.

Contact sprays applied at hatching time are effective against this species, but as has been indicated in the case of other scales with a similar life history, they are hardly practicable.

The Cottony Maple Scale,
Pulvinaria innumerabilis Rathv.

During the early summer months this scale is easily detected by the presence of a white, cottony mass which the insect exudes from beneath the covering scale. (Plate 2, Fig. 2.) Within this mass may be found the eggs, the number varying from a few hundred to two thousand. Hatching occurs during the early summer and the young migrate to the leaves or to the tender young growth, where they settle and begin feeding upon the sap of the tree. Meanwhile a thin scale covering forms over each individual, which with the growth of the insect enlarges and in time turns brown. Before the leaves fall most of the insects migrate to the branches and trunk, where they settle preparatory to passing the winter in their partially grown condition. With the coming of spring maturity is soon reached and the cottony mass already described appears.

The species prefers soft maple, though a number of other trees are subject to slight attack, among the more common being hard maple, honey locust, elm and grapevine.

Two species very closely resembling the one just described attack the hard maple: the maple leaf scale, *Pulvinaria acericola* Walsh and Riley, and the maple *Phenacoccus*, *Phenacoccus acericola* King. The former is found upon the leaves and the latter upon either the leaves or branches.

Natural parasites play an important part in the economy of this insect, in most seasons being sufficiently numerous to prevent serious damage. However, for some reason the natural enemies are not always successful in developing and considerable harm is done by the scale. When the insect becomes sufficiently troublesome to require attention, winter spraying with kerosene emulsion, containing from 12½ to 25 percent kerosene, is the remedy most commonly recommended.

The tests of the value of different spraying materials that have been performed by this department against the insect under consideration have been conducted upon trees only slightly infested, so that the results were not as conclusive as they might have been. A clump of soft maples was divided into plots and sprayed during the latter part of March and early in April, 1907. The following were the mixtures applied: Scalecide, 5 percent solution; Scalecide, 3 percent solution; Limoid, 15 percent kerosene; Limoid, 7½ percent kerosene; Kerosene emulsion, 12½ percent kerosene.

The kerosene-limoid, containing 15 percent kerosene, killed practically all of the scales; the kerosene emulsion sprayed plot came next in order of cleanness and the value of the remaining materials is indicated in the following order: Kerosene-limoid, 7½ percent, scalecide 5 percent and scalecide 3 percent. The weaker solution of scalecide was of little value.

In another section the merits of the lime-sulfur wash and of 17 percent limoid were compared, resulting favorably toward the limoid and in practical failure for the lime-sulfur solution.

The Maple Terrapin or Black Banded Scale, Eulecanium nigrofasciatum Perg.

This insect is sharply hemispherical in form, the adult female is about one-sixteenth of an inch in diameter and the color, though variable, is of a general reddish tone with a more or less distinct blackish band near the border. One of the most distinctive characteristics, however, is the peculiar sickening odor that is especially noticeable when the well grown scales are crushed.

Soft and hard maples suffer most commonly from this pest.

The winter is passed in a partially grown condition, maturity being reached and egg development completed early in June. Usually about the middle of June the young appear.

In the author's experience winter applications of the stronger insecticides commonly used against scale insects have proved unsuccessful in furnishing a control, in fact the insects seemed to be little harmed by the applications. It may be found, however, that kerosene emulsion containing 20 to 22 percent kerosene will bring about the desired results. This, however, cannot be given as an authoritative statement. The emulsion used in the experiments against the pest was only 14 percent kerosene, as it was not deemed safe to use a stronger mixture. Subsequent trials have demonstrated, however, that a hard maple will stand, during the dormant period, applications of an emulsion containing 20 percent kerosene and in some instances will recover from the effect of applications containing 40 percent kerosene. See Plate 4, Fig 2. The hard maple is more liable to injury from the application of strong emulsion than is the soft maple.

The Elm Bark Louse, *Gossyparia spuria* Modeer. The adult females of this insect are the most conspicuous forms. (Plate 3, Fig. 2.) The following description is taken from Memoir 8, N. Y. State Museum. "They may be seen clustered along the under side of the smaller limbs, usually beside a crack or crevice in the bark, and presenting a general resemblance to a growth of lichens. The full grown viviparous females are about 1-10 inch long just before giving birth to their young, oval in outline and with slightly pointed extremities. Each is surrounded with a white, woolly secretion, which also extends partly over the insect and thus renders its segmentation more apparent." The females become full grown in early spring and the young appear during the month of June.

This insect occurs upon the elms in Marietta and according to Burgess in Columbus is not known to occur in any other portions of the state. According to Dr. Felt it is present in the following parts of the Union: Vermont, Massachusetts, District of Columbia, Michigan, Nevada, Colorado and New York.

In June, 1906, the writer made a careful study of the condition of the city of Marietta. The insect was found to occur in various parts of the city, the vicinity of the chair factory being seemingly the center of infestation. It is not known definitely when it was first introduced, nor is there any plausible theory as to how the introduction was made. The trees were not in a serious condition, though some of the limbs were dying. The majority of the scales were upon the lower limbs, though many specimens were found as high as 46 feet from the ground.

What is known as the bitter elm is most subject to attack. The water elm is rarely attacked and, if so, very slightly, even when growing beside infested specimens of the former species.

The progress of the insect will be watched with considerable interest as it is considered a serious pest in some of the localities before mentioned.

June 28, 1906, while the young scales were emerging, an application of kerosene emulsion containing 7 percent kerosene was made to a small elm badly infested. The tree was very thoroughly sprayed, special care being taken to follow out the under side of the limbs. The treatment was successful in destroying the young insects already emerged, but did not seem to affect the females nor the young beneath the mother scale, as the young were noticed emerging in considerable quantity an hour after the conclusion of the treatment.

Prof. R. H. Pettit, of the Michigan Agricultural College, reports success from the use of the lime-sulfur wash upon the elms located upon the college grounds. It is quite likely that this is the most practicable and satisfactory spray to be used.

Tulip Tree Lecanium,
Eulecanium tulipiferae Cook.

The tulip tree lecanium is one of the scales quite frequently received by the entomological department, not that it is especially common, but because it is easily detected. In cases of severe infestation the branches on which it occurs appear irregularly knotted.

Occasionally, fatal results are reported to follow its attack, but in the writer's experience he has never seen a tree killed or severely injured by it. However, the large fleshy scales surely consume considerable of the tree's sap and thus harm it to a certain extent. Applications of control methods are in no wise misplaced. As the scales are so large and so easily detected, probably removing them with a stiff wire brush is the most practicable remedy.

The Pine Leaf Scale,
Chionaspis pinifolae Fitch.

This is a small, elongated, snow-white scale, at the narrow end of which is attached a small yellow pellicle. It is found attached to the leaves of the pine. (Plate 3, Fig. 1.)

The winter is passed in the egg stage. Two broods occur annually, one in early summer and the other during the fall.

During the spring of 1903 the pines on the Experiment Station grounds were badly infested by this insect, some of the trees being in a dying condition. A weak kerosene emulsion was applied at the time the first brood was emerging and a very dilute solution of whale oil soap at the time the smaller fall brood appeared. As a result the trees were almost completely cleared of the pest, and additional treatments have not been found necessary thus far. However, the scale is again obtaining a rather strong foothold and will soon need attention. The insect is illustrated, natural size, in Plate 3, Fig. 1. There is also shown in the illustration an adult of the twice-stabded ladybird *Chilocorus bivulnerus* Muls., a natural enemy of the scale which does considerable towards holding it in check.

The Golden Oak Scale,
Asterolecanium variolosum Ratz.

This scale was recorded at Mentor by Newell in 1900 and was also received from Glendale in 1907. An infested tree stood in a lawn adjoining Edgewater Park, Cleveland, in 1906, and on it, July 19, the young were appearing in immense quantities. The scale is easily determined on account of a yellowish-green golden color and because it causes a slight abnormal growth upon the twig, thus presenting the appearance of being partially imbedded in the bark. Although alive, the trees infested were not healthy, the bark being very rough and uneven and seemingly only partially able to fulfill its duties.

Kerosene emulsion is an effective remedy when applied during the hatching period.

The Pine Bark Aphid,
Chermes pinicorticis Fitch.

Though not a scale, this insect may logically be considered here, as it's appearance is much the same as that of some of the scales and the control methods are similar. The adults are illustrated in Plate 3, Fig. 3, where they may be seen as collected in thick, white, floculent masses upon the base of the pines. The pest has been noticed for the past two seasons upon certain trees in the Experiment Station gardens, and the writer has observed it in lesser quantities than those shown in the illustration upon pines in the Cleveland parks.

The foliage of the trees that are worst infested upon the Experiment Station grounds is beginning to loose color, indicating the vitality of the trees is becoming weakened.

The pest is subject to the action of contact sprays, according to Dr. E. B. Southwick, Entomologist of the New York parks, the stiff sprays being effectual.

THE LEAF EATING INSECTS.

The White Marked Tussock Moth, Hemerocampa leucostigma Sm. & Abb.

This insect undoubtedly heads the list of leaf-eating pests found in Ohio. It is easily distinguished during all stages of it's life history. See Plate 5. Two broods occur each season, the young larvae of the first appearing soon after the leaves are well out upon the majority of the shade trees. The winter is passed in the egg stage.

The eggs are deposited upon the discarded cocoon of the female moth, in a white frothy mass from ½ to 1 inch in length and varies from 200 to 400 in number. The frothy aspect results from the brittle material that binds the mass together.

The larva upon first hatching is a hairy caterpillar about ⅙ inch in length and, while young, has the power of spinning a silken thread with which it lowers itself if the tree is jarred or suddenly shaken by wind. Currents of air, swinging it, may deposit it upon the nearby trees and this is one of the means by which the spread of the insect is effected.

The newly hatched larva feeds for a time upon the epidermis of the lower side of the leaf but as it grows older and stronger more of the leaf is eaten until by the time it is full grown all but the midrib and larger veins are devoured.

The grown larva is one of the most beautiful caterpillars occuring in Ohio. The head is coral red; extending longitudinally along the back is a broken black line bordered by narrower lines of yellow. The yellow bands are bordered by broader ones of drab. Below, the caterpillar is yellow. Projecting forward like horns just above the head are two black tufts of hair ⅓ or more the length of the body, and extending from the opposite end is a single tuft of the same texture, though not quite so long. On the dorsal side of the 4th, 5th, 6th and 7th segments are compact tussocks of pure white hair and on account of this the insect is called the Tussock Moth. The larval stage is of a little over a month's duration. Upon the completion of larval growth the caterpillars become abnormally active, crawling about, seeking a suitable place to pupate. During their wanderings they may travel considerable distances and it is mainly at this time that the advance from tree to tree is effected.

After a satisfactory place has been found in which to pupate, the larva constructs for itself a cocoon, mainly from the hairs of its own body. About two weeks are spent in the pupal stage at the the termination of which the adults appear. The adult female is wingless and never leaves her cocoon until her eggs are deposited as previously described. With the completion of oviposition she dies and usually falls to the ground.

The male has feathery antennae, hairy legs and a wing expanse of nearly an inch. The wings and body are rather definitely marked with varying shades of gray.

For several seasons previous to that of 1907 the insect appeared to be gradually increasing in numbers and in destructiveness in the city of Cleveland. During the early part of the season of 1907, the first brood, which was an unusually large one, was beset by an army of parasites, resulting in a very small second brood of larvae.

A consignment of larvae and pupae placed in the breeding cages gave forth a large quantity of Hymenopterous and Dipterous parasites. In addition to the parasites just named, Heteropterous nymphs, the adult form of which we were unable to obtain, were observed clustered about the cocoons with their beaks inserted into the chrysalid or larva, as the case might be, that was contained therein.

The principal hosts for this species in Ohio are lindens, horse chestnuts and elms.

During the season of 1907, three methods of combatting this insect were given trial. The first consisted in clearing the egg-masses from small elms on Euclid Ave. See Plate 8, Fig. 2. The collecting was done during the spring months. The trees were in a small park removed some little distance from other trees. As a result of the treatment they were unaffected by the insect during the entire summer following. However, as before stated, the trees were small, and the work of clearing them could be very thoroughly done. This is one of the standard methods to be used against the pest.

When the infested trees are very tall, thus rendering collecting impossible, dampening the masses with creosote is sometimes substituted. The operation is performed with a sponge dipped in creosote tied to the end of a long pole. Where trees that have been cleared of the egg-masses are situated in the vicinity of other plantings it is well to supplement the collecting process by banding the trunks of the trees with mechanical barriers, such as rings of cotton batting or bands of sticky material, such as Thum's tree tanglefoot.

The second method given trial during the summer of 1907 was spraying lindens with kerosene emulsion containing 5 percent kerosene and with arsenate of lead, 3 pounds to 50 gallons of water; supplementing the treatment in each case with bands of tanglefoot fly-paper. Ses Plate 7, Fig. 1. At the time of the treatment, the first brood of larva was beginning to give evidence of its presence by its work upon the leaves.

Both sprays killed the feeding larvae and the trees were practically free from the insect during the entire season, whereas, their untreated neighbors were partly defoliated. The sticky materials upon the bands was replenished once during the summer with a coating of Thum's tree tanglefoot.

The third measure looking toward control that was tried experimentally, was the application of strong kerosene emulsion at the time the first brood of larvae was transforming to the pupal stage. Horse chestnuts that had been defoliated by the first brood were heavily sprayed with strong kerosene emulsion July 20. The trees were located in front of 2236 84th St. SE. Directly adjoining these trees were other horse chestnuts that were left unsprayed for comparison. The comparison however was not a fair one as the untreated trees had in no wise suffered as severely as had the others. An idea of the appearance of the tree at that time of treatment may be had from Plate 6, Fig. 1.

August 30, the tree was again photographed as shown in Plate 6, Fig. 2. At the later date scarcely a single larva could be seen upon the treated trees and a small crop of new foliage had grown meantime; while enough larvae had escaped the parasites on the untreated trees to do considerable harm. A comparison between the treated and untreated trees may be drawn from Plate 7, Fig. 2. It may also be seen where some larvae from the untreated tree had gained access by means of the interlocking branches to the treated tree, and had destroyed a portion of the second crop of foliage.

As a general specific measure to be used in combatting this pest, the author believes there is nothing more effective and practical than collecting or treating the egg masses during the winter months and keeping the trees banded with tanglefoot from the middle of June until the first killing frost. This measure is escially commendable for individual operations as the cost would not be excessive to hire nimble workmen to climb the trees and destroy the egg-masses. It would only remain to keep the bands in good working order. If the work of destroying the cocoons is thoroughly done and the trees so treated are not close enough to neighboring trees so that the young caterpillars are able to span the distance with their webs, there is no reason why careful banding alone should not keep the trees free of this pest.

If impossible to collect the egg masses, spraying with arsenicals is next in order but it too should be supplemented with banding and the mixture should be applied while the larvae are young.

The Forest Tent Caterpillar,
Malacosoma disstria Hubn.

During the last half century there have been occasional severe outbreaks of this insect in widely separated sections of the United States, the hard maple being the principal sufferer in the north.

The eggs are deposited in late summer, usually upon the lower branches of the tree, though they sometimes may be found upon the topmost twigs. They are placed in belts of about 150 each surrounding small twigs. After the egg is deposited, the larva develops within the egg-shell, but does not break through until the following spring, about the time the leaves are appearing. As the larvae feed and develop, they do not spin a sheltering web as do some of the other leaf-feeding caterpillars, but, as they pass up and down the limbs of the tree, they spin a silken thread behind them, which after many passages becomes a silken path. When not feeding upon the leaves they rest in clusters upon the limbs and trunk of the tree. They also take this position to shed their skins.

The full grown caterpillar is about two inches in length and is characteristically marked with a blue head and a row of diamond shaped spots down the middle of the back.

The cocoons are spun in any sheltered position, such as among crumpled leaves on or under the tree, in crevices of the bark and of fence-posts, etc. They are composed of the hairs from the insect's body, silken threads, and a liquid which the caterpillar ejects, the latter giving the mass a yellow, powdery appearance.

The adult is a brown moth, bearing a darker colored band across each fore-wing, almost parallel to the outer border. They fly mostly at night.

Concerning remedial measures, as with the tussock moth, much good may be accomplished by collecting and destroying the egg-masses during the winter months. However, this method is not as fully applicable in the present instance as the egg-masses are not so conspicuous. Probably the best method of control is spraying with arsenicals at the time the larvae appear. As with the tussock moth it will probably be of advantage to band to prevent reinfestation.

The Fall Web Worm,
Hyphantria textor Harris.

The distinguishing characteristic of this insect is seen in the large unsightly webs occurring most commonly upon wild cherry during the late summer. Upon critical examination, it is seen that the webs contain a quantity of hairy larvae which feed upon the more or less browned leaves of the twigs enclosed. This discoloration results from the insect's eating the softer portions of the leaves causing the remainder to die. Occasionally, as the larvae approach maturity, the food supply is exhausted within the web and they wander to adjoining twigs. The pupal stage is passed in a thin cocoon, usually located in trash on the surface of the ground or just below the surface.

Both sexes are winged moths, white, or white dotted with black. The eggs are deposited upon the leaves.

Because of the conspicuous web, one of the common methods used in combatting this pest is clipping the twigs from the tree to which the masses are attached and destroying them. This, however, involves a loss of a part of the tree and for this reason it is preferable, where possible, to spray with arsenicals when the young caterpillars are known to be emerging. This occurs during the month of June. See Plate 9, Fig. 2.

The Bag or Basket Worm, Thyridopteryx ephemeraeformis Haworth.

Insects of the class to which the one under present consideration belongs, derive their popular name from the curious bag or basket which is constructed during the larval stage. Soon after the larva is hatched it contructs for itself a silken sack, smooth inside, while to the outside are attached portions of bark, leaf tissue, leaf petioles, etc. From the open end of the bag the larva protrudes its head and fore legs, and thus walks about at will, dragging its home with it. To one unaccustomed to the sight it is indeed a surprise when the curious semi-shapely bundle of trash that has attracted his attention, suddenly develops life and moves away.

As the enclosed larva grows, the bag is enlarged from time to time by additions to the open end. Upon reaching maturity the larva binds its case to a limb and pupates. At the end of the pupal stage the males emerge and fly about, while the females, being wingless, oviposit within their old cases and afterwards wriggle out to fall upon the ground and die.

The winter is passed in the egg stage.

A number of bag-constructing insects occur in Ohio: one, a small species, and quite common, covers its bag with portions of grass stems, and the empty cases may be found attached to fence posts, etc. The one under discussion is a comparatively large species, the completed bag varying in length from 1½ to 2 inches. It was observed doing considerable damage to shade trees during the past season in the central and south-western portions of the state.

A large number of trees and shrubs serve as food plants, the ones most commonly found during the past season being sycamore, horse chestnut, hard maple and willow. The most severe case of attack coming to the author's attention was upon hard maples in Cincinnati. See Plate 11, Fig 2.

Probably the simplest and most effective of the methods to be used in combatting this pest is the collecting of the conspicuous bags during the winter, thus destroying the eggs; followed by the application of mechanical barriers placed around the trunk of the tree, to prevent it from being reinfested by larvae wandering from other sources.

Another remedy applicable during the summer season when the larvae are feeding is spraying with arsenicals. See Plate, 10 Figs. 1 and 2, and Plate 11, Fig. 1.

The Brown Tail Moth, *Euproctis chrysorrhaea* Linn. This species occurs only in the New England States at present, but unless something unforeseen happens it will be only a matter of time until it spreads to this state. The following description is taken largely from Memoir 8, New York State Museum, and is herewith given that the pest may be recognized and prompt measures be taken to stamp it out when it reaches our borders.

The insect has two features peculiar to it which render its separation from other insects comparatively easy. The first is the presence of a tuft of brown hair on the tips of the abdomens of the moths of both sexes, and the second is the position in which the webs are spun, namely, upon the tips of the branches.

The female moth is white in color with the exception of the brown marking already described, and measures 1¾ inches across her spread wings. The male is smaller, having a wing expanse of 1¼ inches, and the general white of the wings is broken with a few black spots. The brown tuft on the abdomen is smaller and darker in color than that of the female.

The moths fly during July, and during this season the eggs are deposited in masses on the under sides of the leaves. From 200 to 300 are clustered together and are then covered with the brown hairs from the tip of the abdomen of the female.

Upon hatching, the young feed gregariously upon the surface of the leaf, spinning a covering web as they go. They soon begin the preparation of their winter nest by drawing a few leaves together and lining them with silk, and binding the whole tightly to the twigs. The winter is passed in the immature larval condition within the protection of the soil.

"Early in the spring the caterpillars emerge and, if the leaves have not started, begin feeding upon the swelling buds. During the spring they continue their work, completely stripping the tree in cases of severe attack. One brood occurs annually.

"When full grown the caterpillars are 1½ inches long. They are dark brown with a sprinkling of orange. Long, fine, reddish hairs cover the body, and a row of conspicuous white hairs runs along each side. Like the caterpillars of the tussock and gypsy moths, they bear bright red eversible tubercles on the top of the sixth and seventh abdominal segments."*

Besides doing great injury to the trees in badly infested districts, the caterpillars are equally obnoxious because of the poisoning effect the spines from the hairs of their bodies have upon human flesh. Contact with the insect's body, with cast skins as they are blown about, with the cocoons or with clothing in which the spines have gained access, may cause the characteristic irritating eruptions.

The cocoons are placed upon the leaves or in some sheltered position. They are lightly covered with the brown hairs from the tip of the female abdomen.

As to food plants, according to Dr. Felt, the insect feeds upon such fruit trees as the pear, apple, plum, and cherry, and upon the following forest trees: oak, maple and elm.

The remedial measures are comparatively simple, consisting of the collecting and destroying of the conspicuous winter nests. Spraying with arsenicals is also to be relied upon, but the former is preferable because of the smaller expense involved.

The Gypsy Moth,
Porthetria dispar Linn.

This, as with the preceding insect, is one that Ohioans may happily say does not occur within the borders of the state. It was introduced into Medford, Mass., in 1868 or 1869, but did not develop in excessive numbers until 1889, when the attacks became very severe in the locality of its introduction.

At that time the state of Massachusetts began making annual appropriations for the purpose of combatting the pest and during the nine years following over $1,000,000 was expended. During that time the insect spread slowly, and since 1899, when the appropriations were discontinued, more rapidly, so that at the present time a considerable area of Massachusetts is infested, and the infestation has spread to at least one of the neighboring states (Rhode Island.)

"The eggs of this insect are deposited usually in round or oval patches on a piece of bark and then covered with the buff-colored scales from the underside of the female's abdomen. A completed egg-mass looks very much like a small piece of sponge. The egg-mass may be found on stones, in tin cans, and in fact on almost any fixed object near at hand, preferably on the under surface, particularly of limbs and fence rails. The nearly globular, pale yellowish or salmon-colored eggs are about one-twentieth of an inch in diameter, and there are usually 400 to 500 eggs in a cluster, though occasionally 1000 may be found in an egg mass.

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*Bul. 108, Maine Agricultural Experiment Station.

"The young caterpillar is slightly over one-tenth of an inch long just after it emerges from the egg. It has a black head, the body is brownish yellow and well clothed with long hairs. There is a prominent hairy tubercle on either side of the segment next the head; this gives the caterpillar a peculiar broad-headed appearance, especially in its early stages. The markings become plainer as it increases in size, and when full grown it is from 2 to 2½ inches long. This caterpillar has a double row of conspicuous warts or tubercles down its back, the eight anterior blue, the 12 remaining red, not counting the four blue ones just behind the head. Similar tubercles also occur on the sides.

"The somewhat conical, dark brown pupa ranges from ¾ to 1½ inches long. It is usually found lying among a few threads and securely attached to them by its terminal spine.

"The male and female moths differ markedly. The former, a slender, olive brown, black-marked creature with feather-like antennae and having a wing spread of about 1½ inches, may be seen flying in the late afternoon and early evening in considerable numbers. The female is much heavier and lighter colored. She has a wing spread of about 2 inches and is a white or buff white color with more or less distinct black markings. The abdomen is tipped with buff. The female moth does not fly though she apparently has well developed wings.

"The winter is passed in the egg-mass, which is remarkably resistant to atmospheric and other agencies. Experiments have shown that even when the egg clusters were broken up and freely exposed to the elements, the eggs were apparently not harmed, and a normal proportion of the caterpillars appeared at the usual time, which, in the vicinity of Boston, is from the last of April until the middle of June. The feeding period extends from the first of May to about the middle of July, a caterpillar requiring from about 9 to 11 weeks to complete its growth and enter the pupal stage. The young caterpillars remain on the egg clusters from one to five or more days and then commence feeding on the leaf hairs. Soon they eat out small holes in the leaves and, after the third or fourth molt, about as many feed on the edge of the leaf as eat out holes. The caterpillars are largely nocturnal, remaining in clusters on limbs and trunk, or hiding in some crevice during the day, and beginning between 7 and 8 o'clock in the evening leisurely to ascend the tree, where they feed on the foliage at intervals during the night, descending about 3 o'clock in the morning.

"The larvae transform to pupae during the month of June, the moths appearing from the latter part of June till the latter part of July. In exceptional cases these dates may be considerably extended. Males emerge in advance of the opposite sex, and shortly afterwards the females appear, pairing takes place and egg deposition begins. The embryos are frequently well developed within the egg in two or three weeks after oviposition, but as a rule the caterpillars do not emerge till the next spring. A case is on record of eggs hatching in early September, 1895, at Woburn, Mass., but the round of life was not completed, and in this northern latitude at least, there need be little fear of two generations annually."*

The insect feeds upon the foliage of practically all of the shrubs and plants grown for economic and ornamental purposes.

Concerning recommendations for combatting this pest, Dr. Felt has the following to say:

"Investigate anything that arouses a suspicion that it may be the gypsy moth, but be in no undue haste to identify the insect. It will be much more satisfactory to submit the specimens to an entomologist than to arouse unnecessary fears. There have already been several false alarms occasioned by persons with more enthusiasm than discretion, who have attempted to identify an insect with which they were unacquainted.

"It would undoubtedly pay to exterminate a small colony, but in the course of time this will be impracticable. We must learn to control it on our own land. The inability of the female to fly and the conspicuousness of the egg-masses make this task relatively easy, unless the pest is allowed to escape to the woods. There, a private individual could hardly cope with the insect. The point of establishment in this state is almost bound to be near some dwelling, and therefore the species need not be allowed to establish itself in wild land, at least for some years.

"One of the most effective methods of keeping this pest under control is the careful collection and burning of the conspicuous egg-masses. This can be done most effectually in the fall, during the winter and in early spring. No ordinary fire running over the ground can be relied on to kill the eggs. The only safe way is to put them in a stove or similar fire and burn them. Creosote oil applied to the egg-mass will soak in and kill the eggs. The following preparation was used in the work against the gypsy moth: Creosote oil, 50 percent; carbolic acid, 10 percent; spirts of turpentine, 20 percent, and 10 percent of coal tar. The latter was added to color the compound and thus show at a glance what clusters had been treated."†

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*Insects Affecting Park and Woodland Trees. N. Y. State Museum Memoir 8.
†Ibid.

"The caterpillars prefer to hide during the daytime, and advantage may be taken of this habit to tie burlap bands in the middle around the tree trunks and then turn the upper portion of the burlap down over the string. The bands can be lifted daily and the caterpillars beneath killed. This method proved of such great value in the work against the gypsy moth that thousands of trees were banded during the latter part of the caterpillar season."

"The larva is quite resistant to arsenical poisons, and it requires a large dose to kill it, especially when the caterpillar is nearly grown. There is probably no better poison for this pest than arsenate of lead, using at least 5 pounds to every 50 gallons. The application should be made as soon as the leaves are well grown, and then the caterpillars will be poisoned while young and most susceptible to the insecticide."

Spiny Elm Caterpillar or Mourning Cloak Butterfly, Evanessa antiopa Linn.

The adult of this species is one of the butterflies quite commonly seen flying about. It is strikingly marked by the general dark-brown color of the wings being bordered by a margin of broken yellow, the whole general appearance being that of black bordered with white.

The eggs are deposited in rings around the twigs of the food plant, which for Ohio is usually willow, though elms are sometimes attacked. The full grown larva is black with a row of red spots down the back. It bears numerous long spines which in turn bear shorter branches. It measures about two inches in length. The pupal stage is passed as an unprotected chrysalid attached to some portion of the food plant. The winter is passed in the adult stage in some sheltered nook.

Control methods consist in spraying with poison, or in collecting the larvae and destroying them as they feed in clusters.

Black Walnut Caterpillar, Datana integerrima Grote & Robinson.

The general body color of the larva of this insect varies from dark brown to black, and it is clothed in long, white hairs. When disturbed it suddenly raises both ends of the body to a vertical position, holding only with the body legs. This peculiarity, in combination with its general color, renders the insect comparatively easy to distinguish. The full grown larva is about 2 inches in length. It has been observed by the writer feeding on black walnut only, though it is reported from other states as feeding upon butternut, hickory and others.

The larvae feed in clusters on the leaves and at certain intervals travel to the trunk or larger branches of the tree for the purpose of molting, leaving a silken path as they go. They settle in a large mass to cast their skins and after the completion of the operation pass back along their well marked trail to their feeding grounds. A considerable quantity of the cast skins remains attached to the tree at the point where the cluster of larvae rested. They again travel *en-masse* when they pass to the ground to pupate.

The insects may be destroyed in great quantity while they are settled upon the trunk of the tree during their molting period, or the crop of insects for the following season may be considerably lessened by thoroughly working the ground beneath the tree during the winter months to destroy the hibernating pupae.

The Catalpa Sphinx,
Ceratomia catalpa Bois.

This insect has been known to occur in Ohio for a number of years. It is only since the catalpa has become so popular as a tree for forestry purposes that the catalpa sphinx has attracted very much attention. Its ravages are confined mainly to the southern part of the state.

The insect, as represented in the different stages of its development by Plate 12, is most easily detected by its work upon the leaves during the larval stage. The tiny worms may be observed feeding in rows or clusters upon the epidermis of the leaf. Later the whole leaf is eaten and in case of bad attacks the entire tree is defoliated, as represented in Plate 13, Fig. 1. The larva is first of a pale yellowish-green color and bears a black horn or spine at the rear of the body. When full grown it resembles the large green tomato or tobacco worm, with the exception that the color, instead of being solid green, is green with broken black bands extending lengthwise of the body. The worms may be observed in Ohio at least twice each season—once in June and again in late summer. Possibly there are more than two broods.

The larva pupate under the surface of the soil, the pupa proper being reddish brown, and somewhat smaller than that of the tobacco sphinx. It also lacks the peculiar "jug handle" common to the other species.

The moth is of the regular sphinx type; pointed body, narrow, strong wings, large eyes, and is of a gray ashy color. The eggs are deposited in pearly masses on the under sides of the leaves. The winter is passed in the pupal stage.

Three methods of control are practicable to be used against the pest. The first is collecting the egg-masses or clusters of newly hatched larvae. The second method is spraying with arsenicals. The third, recommended in Bul. 7, Ohio Department of Agriculture, Division of Nursery and Orchard Inspection, relates to the control of the species in nurseries or plantations and consists in deep plowing at the time the insects are in the pupal stage.

The Catalpa Bud Gnat. The work of this insect upon the catalpa was first mentioned in Bul. 7, Ohio Department of Agriculture, Division of Nursery and Orchard Inspection. During the early summer, the tender growing tips of the catalpa become swollen and in time blacken at the point of injury. During the early part of the season the injury is usually found 3 or 4 inches below the tip, and at a lesser distance during late summer when the tree is growing less rapidly. The tip above the injury dies. Following the death of the tip in early summer, the next node below develops one or more branches and frequently a cluster of leaves, giving the tree a bushy growth. Plate 24. The ultimate result after continued topping is a stunted, crooked, forked, growth—Plate 13. Fig. 2.

An examination made last spring of all the twigs upon 15 three-year-old catalpa trees revealed the fact that 49 percent of the tips of the twigs had been injured by the bud gnat.

If one of the injured twigs is examined by being cut open, small, footless, yellow or white larvae will be found. If one of these is placed on a smooth surface, it has the power to jump several inches in the air. This is accomplished by raising both ends of the body so that they almost meet above, and then with a sudden motion straightening out.

The insect has been under observation on the Experiment Station farm since the summer of 1904. From observations made in the field there appear to be two broods per annum, one in early and another in late summer. The pupal stage is probably passed under the surface of the soil, as the author was unable to secure adults by placing twigs infested with the larva in cages that did not contain moist soil.

With so little understood concerning the pest it is difficult to plan remedial measures. It has been suggested in Bul. 7, Ohio State Department of Agriculture, Division of Nursery and Orchard Inspection, that cutting the infested twigs and destroying them would be of value during the summer.

The Station plantings at Wooster indicate that the pest is less serious in cultivated groves than in sodded ones. However, this observation can only be considered as an indication, as the cultivated groves are younger than the sodded ones and the insect has thus been unable to become so well established.

The Elm Leaf Beetle, Galerucella luteola Mull. This insect was first discovered within the borders of this state by Mr. G. A. Runner of the State Nursery and Orchard Inspecting Department. It was found during the summer of 1904 feeding upon the elms located in the grounds of the National Cash Register Co., Dayton, Ohio. Subsequent examinations revealed its presence in a number of parts of the city.

In July, 1907, the writer made a visit to the city, and found the elms in some sections to be in very bad condition. At that time, as far as the writer was able to learn, work of combatting the insect had been commenced in three places only, one being on the grounds of the Cash Register Company, where arsenical sprays had been applied, and the remaining two were near the center of the town, where some work in banding had been executed by Mr. C. F. Harbison in cooperation with the Agricultural Experiment Station.

Because of the absence of the chief gardener, in whose charge the work had been placed, the writer was unable to obtain a very definite idea of what had been accomplished towards controlling the insect on the grounds of the Cash Register Company.

The plan worked upon by Mr. Harbison was to band the trees with tanglefoot and burlap when the larvae first began to descend, and to examine the bands at frequent intervals throughout the season, destroying all larvae or pupae that collected on or under the bands or at the base of the tree. Although most carefully executed, the banding process was only partially successful in controlling the pest.

The elm leaf beetle is well distributed in the eastern states, and now annually ruins great numbers of shade trees. The green and black striped beetles, not over ⅜ inch in length, pass the winter in the adult stage in some sheltered place. With the coming of spring they leave their shelters and begin feeding upon foliage of the elm. Soon the eggs are deposited on the under sides of the leaves and within a few days the larvae appear. They feed upon the undersides of the leaves, leaving the vein work and epidermis above. Soon the injured portions of the leaf die and the leaves appear as illustrated in Plate 15, Fig. 1.

The grubs become full grown in from 2 to 3 weeks, or possibly longer, depending upon the weather conditions. At the conclusion of larval development the insects crawl about and either pupate in the crevices of the bark or in some nearby shelter. Often they may be seen lying helpless in considerable quantities at the base of the tree.

It is quite likely that only two generations occur annually in Ohio. Elms only are attacked.

Spraying with arsenate of lead, used at the rate of 5 pounds to 50 gallons of water, as soon as the young leaves are well developed is the most satisfactory remedy for combatting this pest. If the application be made at that time, many of the adult beetles will be destroyed and egg-laying prevented.

The banding process undoubtedly does considerable good, but the labor involved in watching the bands renders the cost out of proportion to the good accomplished. See Plate 15, Fig. 2.

The Locust Leaf Miner,
Odontota dorsalis Thumb.

This insect has occurred in destructive numbers for several years in Ohio, the most severe attacks being upon yellow locust, both in plantings and in the wild hillside growth along the southern border of the state. It may be found in the vicinity of Wooster, but very scatteringly. Along the section bordering the Ohio River, the locusts suffer so severely as to cause the browning and shedding of the leaves, large areas appearing as if scorched by fire.

The adult is a flattened beetle about ¼ inch in length. The general color is red, broken by a medial line, with head, appendages and under surface black. The wings are deeply dotted with fine punctures.

The winter is passed in the adult stage under trash in the vicinity of the feeding ground. In the spring the beetles emerge soon after the leaves of the locust are well grown. Eggs are deposited upon the surface of the leaves, and the young larva makes its way out through the under side of the egg-shell into the tissue of the leaf, feeding until grown and pupating between the two layers of epidermis. The adults feed upon the leaves and may be found in the groves throughout the summer. The most satisfactory method of combatting the pest is spraying thoroughly with arsenicals as soon as the locust leaves are out, that the beetles may be killed before egg laying is accomplished. This of course is impracticable for forest plantings.

The Locust Borer,
Cyllene robiniae Drury.

So destructive is the work of this insect upon locust trees that in some places the growing of a perfect tree is an impossibility. The adult belongs to that class of insects known as the long-horned borers. It is a black beetle, brilliantly marked with yellow lines; the long antennae and the legs are dull yellow and the length varies from 1½ to 1¾ inches.

At the time the golden rod blossoms the adults appear and egg-laying commences. The female hurries about over the trunk of the tree, and when a crevice is found which suits her fancy she deposits a single white egg, then continues her search for another place. The eggs are shown much magnified in Plate 17, Fig. 1.

The newly hatched larva bores through the outer layer of bark and rests in the white layer next the wood through the winter. With the advent of spring feeding is resumed, and the larva eats its way well into the body of the tree. If the tree is small the trunk may be almost severed and a slight wind may blow it over. See Plate 17, Fig. 2.

The full grown larva is a creamy, club-shaped, footless grub, about ¾ inch in length. See Plate 16, Fig. 2.

The pupal stage is passed within the burrow, the adult emerging at the time previously stated. There remains to be found a practicable, effective, combative measure for this pest. Spraying the trunks of the trees with a repellant just previous to the time the females deposit their eggs is of some value, though not wholly effective. Whale oil soap and white-wash were applied to adjoining rows of trees in the Station planting, resulting in a slightly lessened injury during the season following. Injecting carbon bisulphide into the tunnels, by the use of an engineer's oil can, previous to the appearance of the adults and closing the tunnels with grafting wax was also partially successful in controlling the pest.

The Locust Twig Borer, Ecdytolopha insiticiana Zell. The presence of this insect in yellow locust groves is quite easily detected by its work upon the twigs of the tree. The smaller twigs become swollen and after a time white, sawdust-like material commences to drop from an opening in the enlarged section (Plate 16, Fig. 1.) The injury is the work of a lepidopterous larva, which, upon the completion of growth, drops to the ground and pupates among the dried leaves. In this position the winter is passed. Although not exceptionally injurious it harms the tree to a certain extent. It is a question, however, whether combative measures are worth while. Should action be considered necessary, the affected twigs may be cut and burned while the larvae are still present in them, or the leaves containing the hibernating pupae may be collected and destroyed during the winter.

SPRAYING APPARATUS.

Power sprayers connected with large mixture tanks are the most practicable for general operations against shade tree pests, as only a strong pump is able to elevate the mixture to the top of tall trees, and the work in doing so is enormous if it is attempted by hand. The city of Cleveland has two of these sprayers, driven by small gasoline engines, which are giving very good satisfaction. See Plate 20, Figs. 1 and 2. One of these sprayers has a platform built above the pump and engine upon which the men stand when spraying the tops of large trees. The sides of the platform are closed, thus protecting the machinery from the spraying mixtures.

A power sprayer, such as either of the ones illustrated, is capable of supplying three lines of hose, and with the proper attention, of distributing 700 to 1000 gallons of mixture per day.

However, it is not always possible to take a large spraying outfit to the scene of operations, and in such an event a smaller machine is desirable. The outfits illustrated (Plate 19, Figs. 1 and 2) supply such a need very well.

Aside from the difficulty of application in cities, another obstacle is the matter of the preparation of the sprays. Insect outbreaks are liable to occur in widely separated districts, so that it is impossible to have a central spray-house easily accessible from all points. The difficulty is especially emphasized in the work with the lime-sulfur wash, or in fact, in the preparation of any spray requiring considerable apparatus. The problem has been largely solved by the city of Cleveland by mounting a steam boiling plant on wheels. Plate 18, Fig. 2. This rig is taken to the scene of operations and stopped near a water plug. A plant of this kind with its four barrels for boiling the mixture and heating water is easily capable of furnishing material for one power sprayer.

The rig was also used to excellent advantage in the preparation of kerosene emulsion. Plate 18, Fig. 1. The soap and water were placed in a barrel and the steam turned on until the soap was dissolved. The kerosene was then thrown in and the steam, rushing out, formed a perfect emulsion in an exceedingly short time. Such a rig is capable of furnishing emulsion for three or four power sprayers.

SPRAYING FORMULAE.

In the general application of insecticides, the materials divide themselves into two classes according to the manner in which they affect the insect. The first includes the contact sprays which are used against insects possessing mouth parts constructed for piercing the covering tissue and taking out the sap of the plant. Of this class the lime-sulfur wash, kerosene emulsion, etc., are well known illustrations. The idea in their application is to cover the body of the pest with the spraying mixture.

The second class of sprays is used against insects that bite out portions of the plant. The active element in them is some poisonous substance such as arsenate of lead, Paris green, etc. They are applied to the surface upon which the insect feeds.

CONTROL INSECTICIDES.

The lime-sulfur wash.

Lime	20 lbs.
Sulfur	15 lbs.
Water	50 gals.

The lime is placed in the boiling receptacle and water added. (preferably hot) in small quantity until slacking is well under way. The sulfur is then thrown on either dry or in the form of a paste, and water is added as necessary to keep the mass sloppy. Upon the completion of the slacking process, water to make 15 gals. is added and the whole is boiled for an hour. At the end of the boiling period water, hot or cold, is added to make 50 gals. and application is made as soon as possible. A steam cooker is more satisfactory than a kettle over a fire, as less stirring during the boiling process is necessary and the mixture thus made is more even in quality.

For more detailed instruction concerning the preparation of this wash, the reader is referred to bulletin 169 of this station.

It may be safely said of the lime-sulfur wash that it is the most generally employed of the scale-destroying sprays. In its use, however, care must be taken that the cooking is done thoroughly lest the lime and sulfur fail to combine properly, and conditions must be favorable at the time of application. The spray should not be applied when the temperature is below freezing.

Kerosene Emulsion

Kerosene	2 gals.
Soap	¾ lb.
Water	1 gal.

Heat the water and dissolve the soap in it. While boiling hot, pour into a convenient receptacle into which has previously been placed the kerosene, and agitate thoroughly until a thick creamy mass results from which the oil does not separate. A spray pump serves admirably for this purpose, as the mixture may be pumped back into itself. Where the sprayer is not available an old churn and dasher serve the purpose admirably.

After the emulsion is perfect, it may be diluted with water to the consistency desired which varies with the insect to be combatted.

Whale oil soap solution This is a very convenient spray to use where it is not convenient to prepare kerosene emulsion. It is made by merely dissolving the soap in hot water in the proportion desired.

Kerosene-Limoid The principle involved in the preparation of this emulsion is practically the same as in kerosene emulsion, the difference being that a very fine lime is used as the emulsifying agent instead of soap. A special kind of lime containing about ⅓ magnesia is prepared by the Chas. Warner Co., Wilmington, Del., and is called Limoid. Prof. C. P. Close of the Delaware Experiment Station reports that any dry-slacked, finely powdered lime is good for the purpose.

The kerosene and lime are mixed in the proportion of one gal. kerosene to 4 lbs. lime, or in other words, the lime is added to the kerosene until all the kerosene is absorbed. It requires from 3 to 5 minutes to thoroughly mix the mass. When the emulsion is complete, it is diluted with water and applied. For scale insects, upon which the mixture is most commonly used, the following are the proportions: kerosene 12½ gal., lime 50 lb., water 34½ gal.

Scalecide and other so-called Soluble Oils Materials of this class require dilution with water only; usually 5 percent mixtures are recommended by the manufactures for scale applications.

In the experience of Prof. P. J. Parrott of the New York Experiment Station, mixtures containing 7 to 10 percent of oil applied to trees infested with the San Jose scale, gave results slightly inferior to those obtained from the use of boiled lime-sulfur sprays.

POISON SPRAYS.

The poison sprays in most general use at the present time are Arsenate of Lead and Paris Green. Of the two, the lead is the most expensive but the extra expense is usually justified by reason of its superior adhesive qualities and consequently longer period of efficiency after the application. The Paris green is more quickly effective than the lead.

Arsenate of Lead This material is manufactured by a number of companies and is placed on the market under varying trade names. It is paste-like in consistency, requiring only the addition of water before use. Some brands are with difficulty dissolved, and for these the author has found the work of the process of preparation much lessened by placing the paste in a small burlap sack and, with frequent dippings in the spraying mixtures, work the materials through the cloth.

For most leaf-eating insects three pounds of material to 50 gal. is sufficient, while for others 5 to 7 lbs. to the same amount of water is more desirable.

Where it is impossible to obtain the manufactured article or for any reason undesirable to do so, arsenate of lead may be prepared after the following formula:

Acetate of lead	11 oz.
Arsenate of soda	4 oz.
Water	50 gal.

Dissolve the acetate of lead and arsenate of soda separately in 2 quarts of water each. Pour the two together and add the desired amount of water.

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*Bulletin 28, New York Agricultural Experiment Station.

Paris Green Paris Green is mixed with water at the rate of one pound to 100 or 150 gal. of water. Two or three pounds of lime are added to prevent burning. The mixture settles readily to the bottom of the sprayer, rendering frequent agitation necessary.

REMARKS.

As stated at the outset, the problem of the control of shade tree pests is one to be encountered to the greatest extent in cities and towns, and is largely a municipal matter. Already steps are being taken in some cities, Cleveland being the most advanced in the matter in this state.

The city of Cleveland has authorized the Department of Forestry to extend its operations to the combatting of the shade tree pests, and to this end has commenced the purchasing of suitable apparatus for the purpose.

The personnel of the department consists of a Forester, Assistant Forester, clerks, and a number of "tree wardens." To the latter are assigned certain sections of the city. Besides their duties of planting, trimming, etc., as far as possible each is supplied with a spray pump mounted on wheels which he uses to the best of his ability. The two large power sprayers, before mentioned, travel about over the city to the points where the work is most needed.

At present the work of the department is confined to the street and park plantings. It is very necessary, however, that the Department be allowed to expand, until it is able to care for trees on private grounds as well, as it loses much of the good effects that should follow the work, because treated trees are reinfested by adjoining untreated ones. Possibly a fair sum could be charged the property owners for the service rendered.

It is evident that all cities and towns cannot afford such an institution as the Cleveland department, but it is the author's opinion that the public sprayer most nearly approaches the solution of the shade tree insect problem for the cities and towns of our state.

ACKNOWLEDGEMENTS.

The author wishes to express his appreciation to Prof. H. A. Gossard, Entomologist of the Station for his suggestions and approval of plans for work; to Mr. M. H. Horvath, former City Forester of Cleveland, and to Mr. John Boddy, the present Forester, for their cooperation with the Experiment Station in the conducting of experimental work, and to Mr. C. R. Neillie, of the same department, for being accorded the opportunity from time to time to examine the records of the work done by the power sprayers; and to Mr. W. H. Goodwin for preparation of one or two of the illustrations, among them the cover cut.

EXPLANATION OF PLATE I.

Fig. 1. The oyster shell bark louse much enlarged.
Fig. 2. The oyster shell bark louse enlarged two diameters.
Fig. 3. Branch of horse chestnut defoliated by oyster shell bark louse.
Fig. 4. Scurfy bark louse much enlarged.
Fig. 5. Scurfy bark louse, enlarged two diameters.

PLATE I.

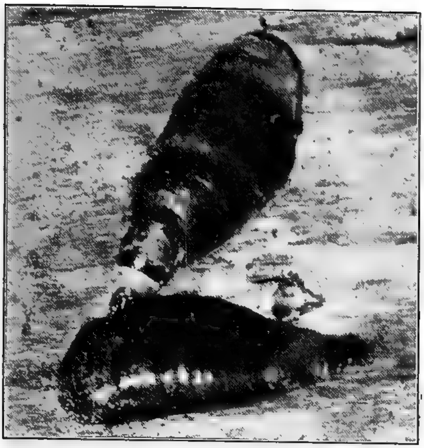


Fig. 1.

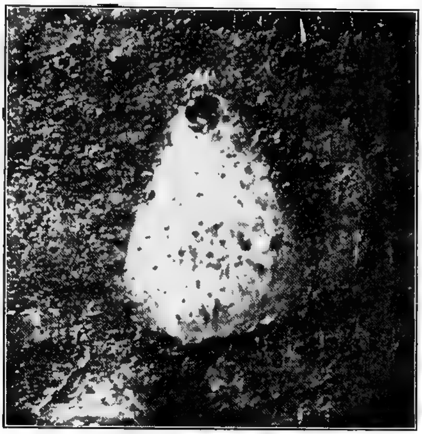


Fig. 4.

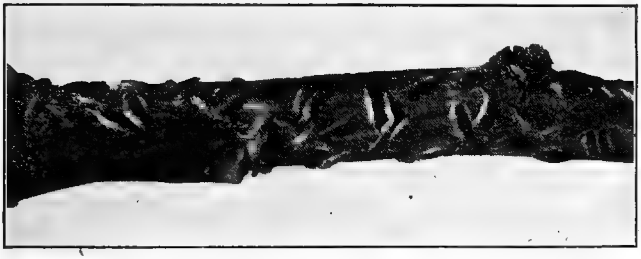


Fig. 2.

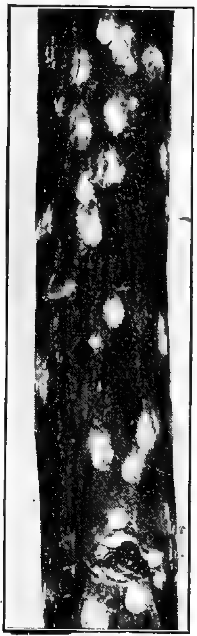


Fig 5.

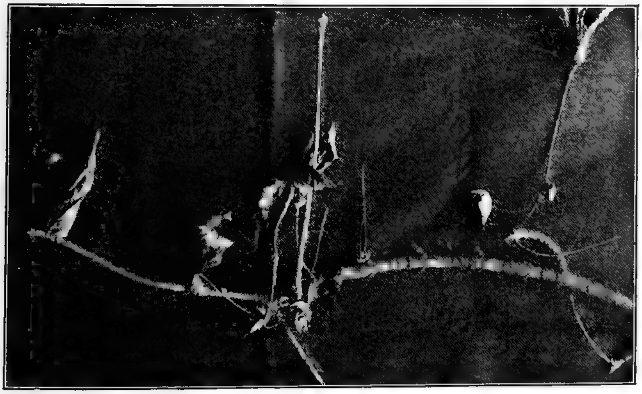


Fig. 3.

EXPLANATION OF PLATE II.

Fig. 1. The rose scale, natural size.

Fig. 2. The maple cottony scale, natural size.

Fig. 3. Lombardy poplar on the campus of Buchtel College, Akron, Ohio. This tree is badly infested with oyster shell bark louse. The horse chestnut is badly infested at the base; the next in order a little less so; the next one a little less, etc., down the line. It is a most striking illustration of how scale insects spread from a badly infested center.

PLATE II.

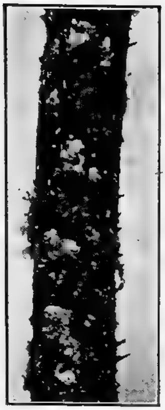


Fig 1

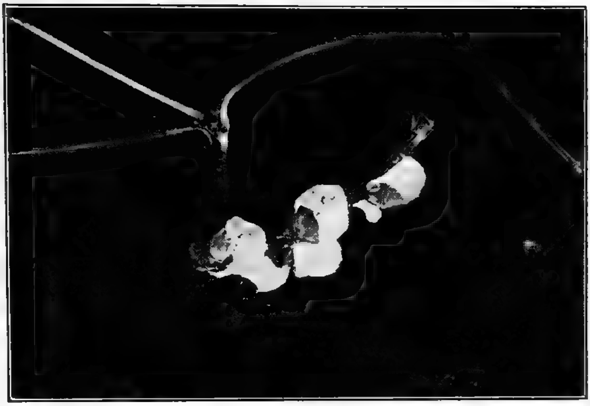


Fig. 2.

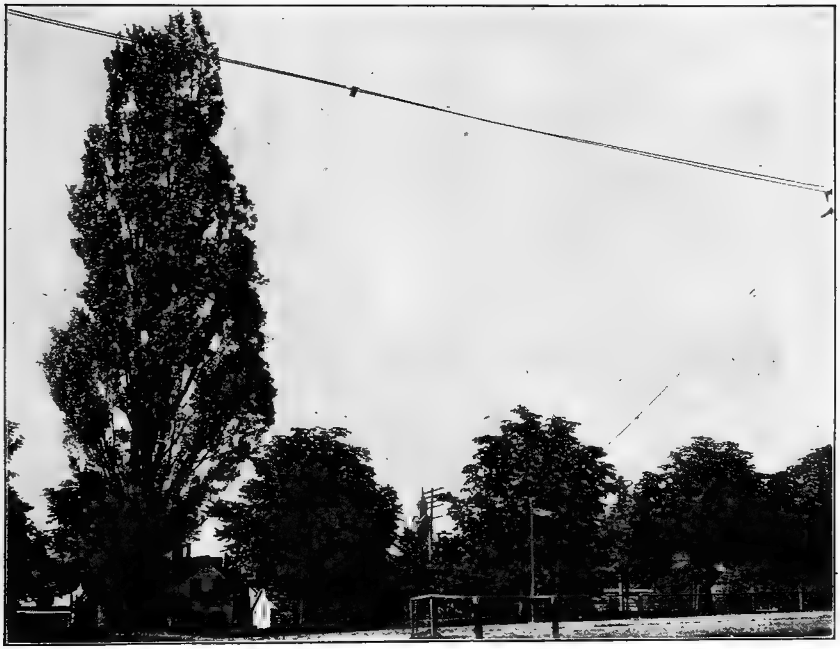


Fig. 3.

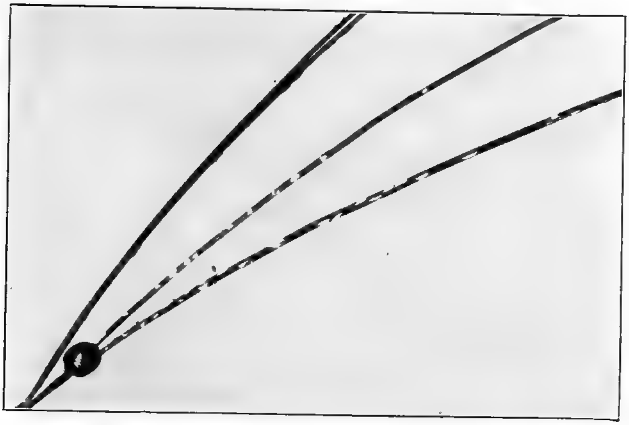
EXPLANATION OF PLATE III.

Fig. 1. The pine leaf scale, natural size, with the twice-stabbed lady bird, *Chilocorus bivulnerus* Muls., feeding upon the scales.

Fig. 2. Adult females of the elm bark louse.

Fig. 3. The pine bark aphid upon the base of a pine.

PLATE III.



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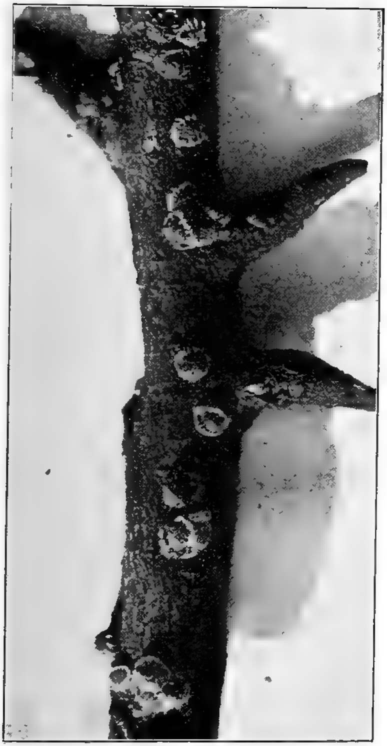

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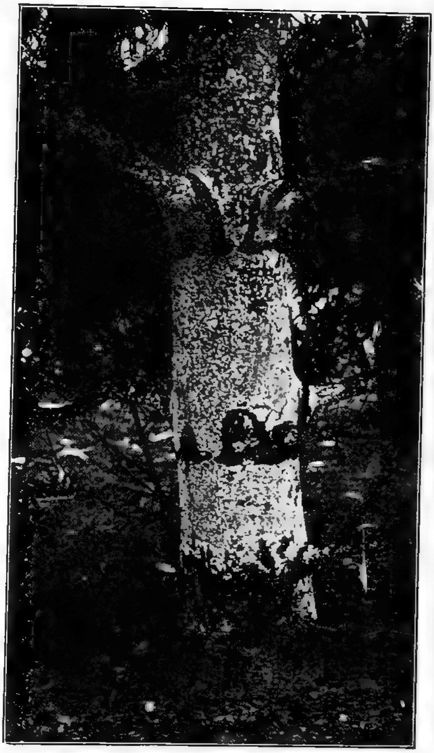


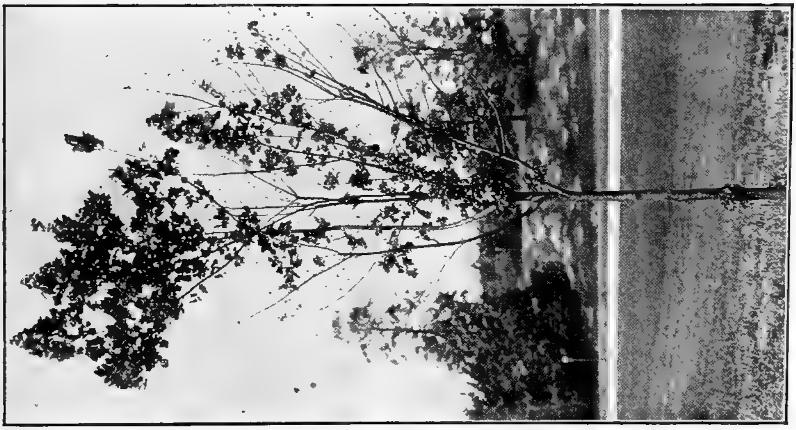
Fig. 3.

EXPLANATION OF PLATE IV.

Fig. 1. Hard maple sprayed during the early spring with kerosene emulsion containing 40% kerosene. The tree was severely injured.

Fig. 2. Hard maple sprayed with kerosene emulsion containing 20% kerosene. Uninjured.

PLATE IV.



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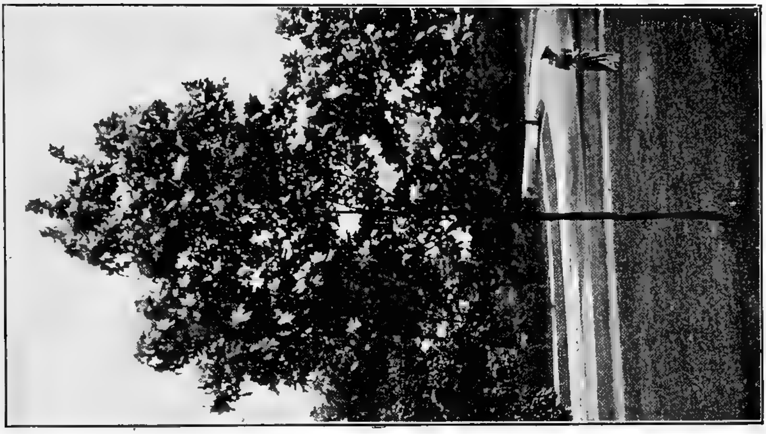


Fig. 2.

EXPLANATION OF PLATE V.

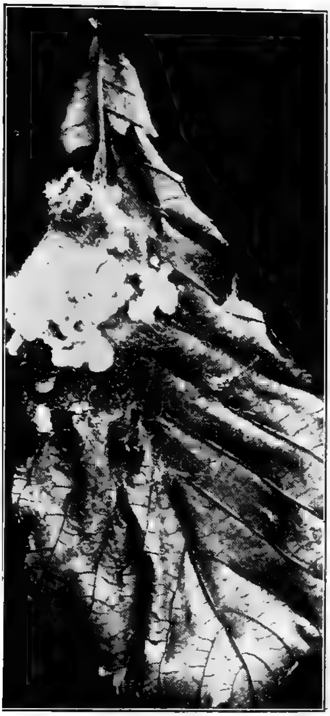
Fig. 1. Egg mass of white marked tussock moth.

Fig. 2. Adult female moth about to oviposit upon her empty cocoon. Slightly reduced.

Fig. 3. Full grown larva.

Fig. 4. Mass of cocoons spun in a cavity on the underside of a branch of horse chestnut.

PLATE V.



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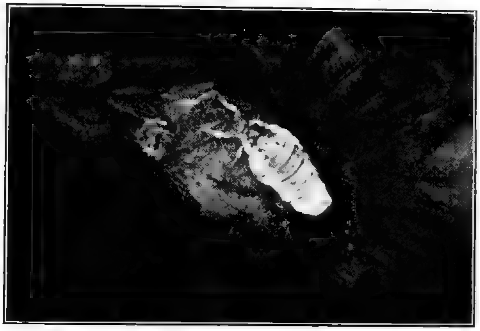

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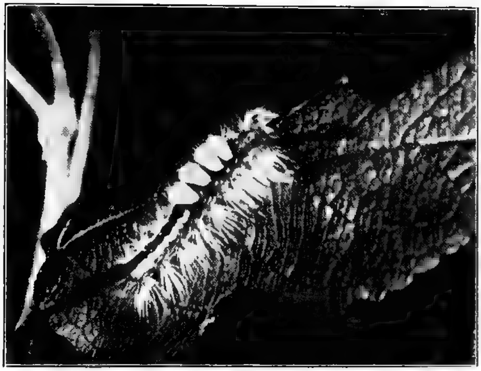

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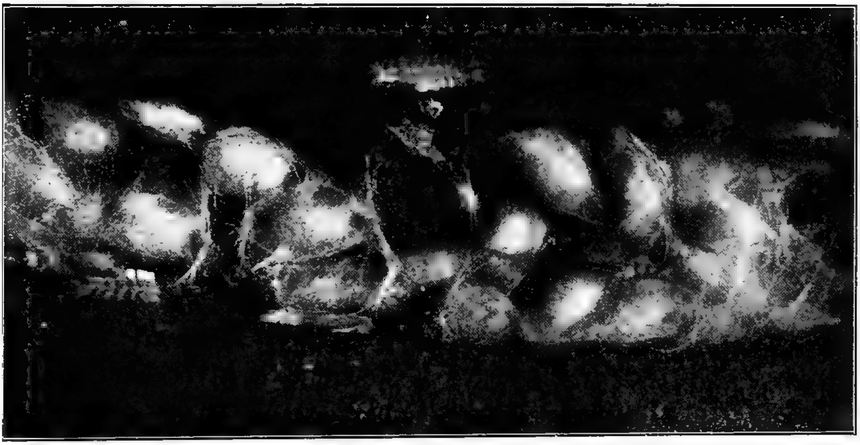


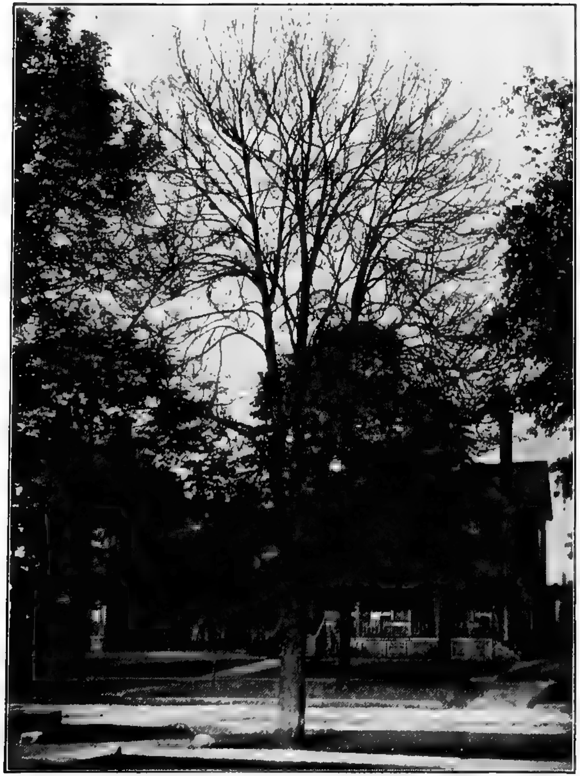
Fig. 4

EXPLANATION OF PLATE VI.

Fig. 1. Horse chestnut photographed July 20, 1906, after it had been defoliated by the first brood of tussock moth larvae. The larvae, at the time the photograph was taken, were transforming to the pupal stage, many having already completed the operation. The tree was sprayed with strong kerosene emulsion and banded with tanglefoot.

Fig. 2. The same tree, as above described, 40 days later. Evidently most of the larvae were destroyed by the treatment, as the tree had grown a partial second crop of foliage. Compare with Fig. 2, Plate VII.

PLATE VI.



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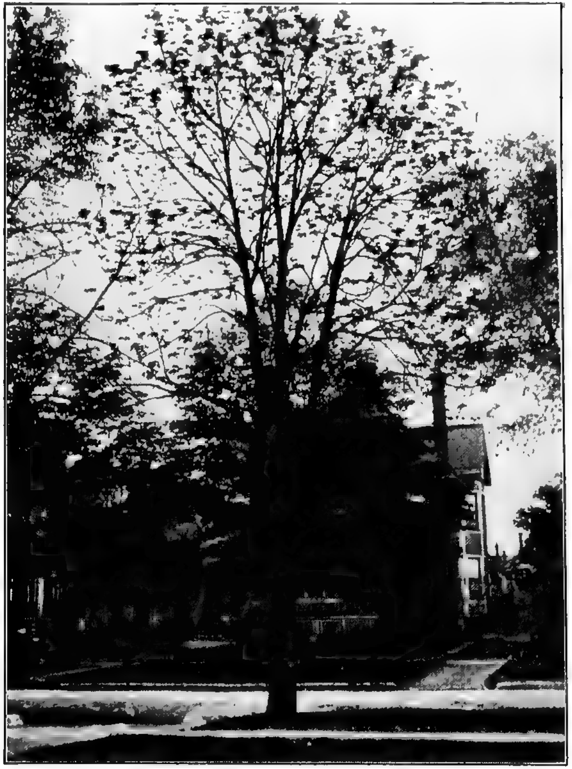


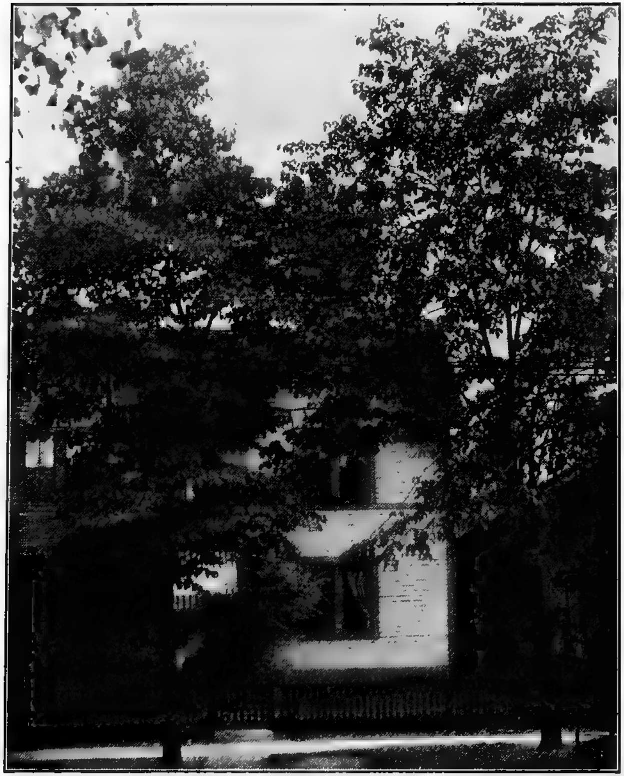
Fig. 2.

EXPLANATION OF PLATE VII.

Fig. 1. Elms protected from tussock moth by spraying with arsenicals supplemented with banding.

Fig. 2. Elm growing beside the one represented in Plate IX, Fig. 2. Untreated. Photo Aug. 30, 1906.

PLATE VII.



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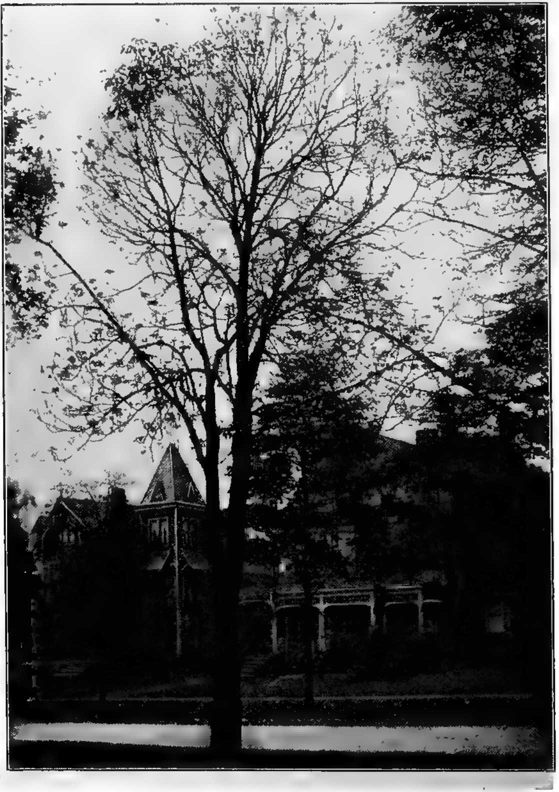


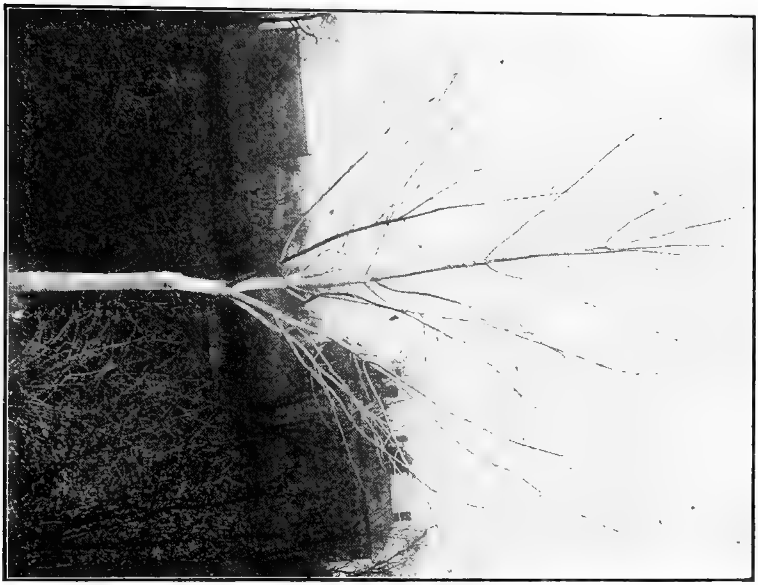
Fig. 2.

EXPLANATION OF PLATE VIII.

Fig. 1. An ash tree perfectly sprayed with lime-sultur wash.

Fig. 2. An elm protected from tussock moth by collecting the egg-masses during the winter.

PLATE VIII.



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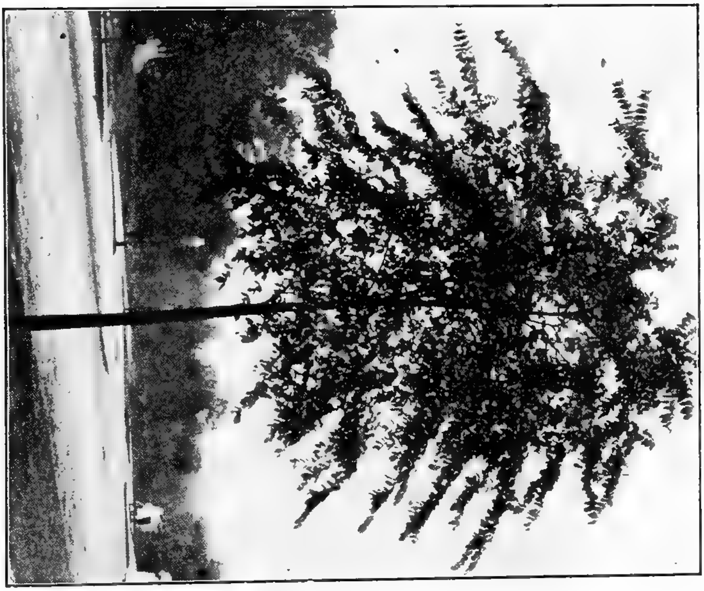


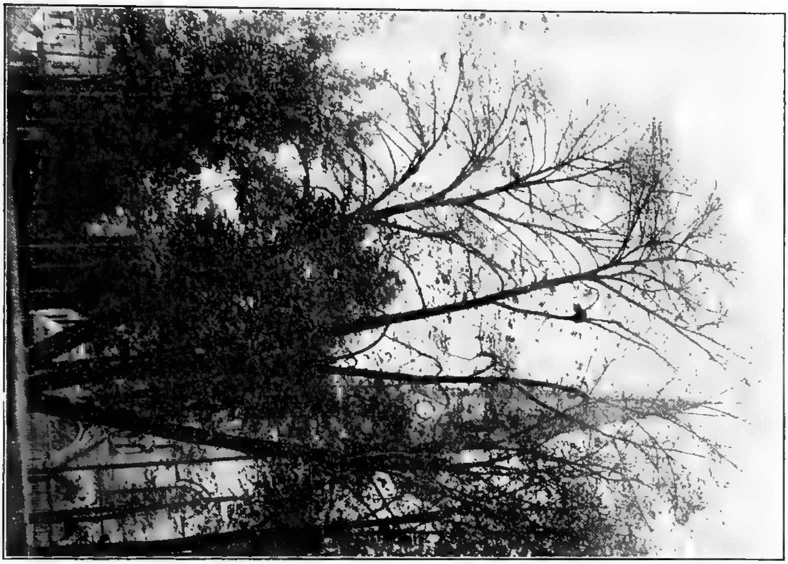
Fig. 2.

EXPLANATION OF PLATE IX.

Fig. 1. Elms located in Washington Park, Cincinnati, Ohio, defoliated by tussock moth July, 1907.

Fig. 2. Sycamore near Howard Street Station, Akron, defoliated by fall web worm.

PLATE IX.



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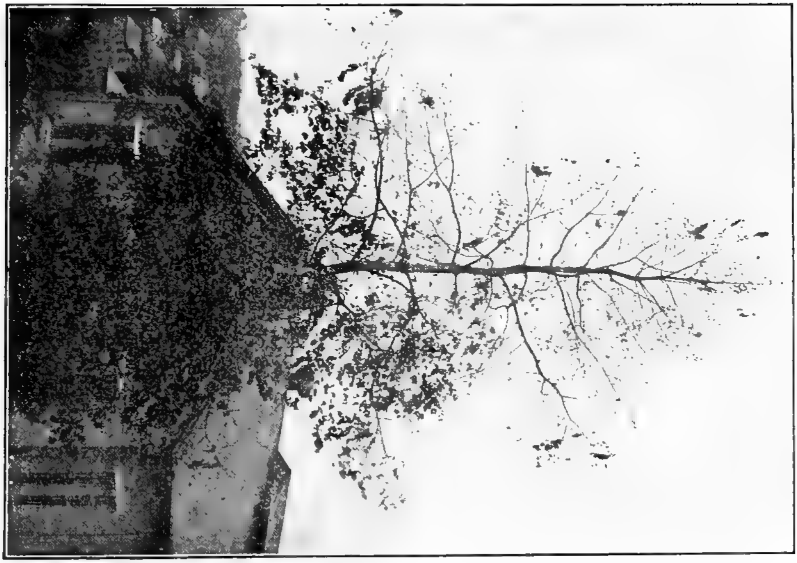


Fig. 2.

EXPLANATION OF PLATE X.

Fig. 1. Bags of bag worm on arborvitae. Photo by Newell.

Fig. 2. Branch of hard maple badly injured by bag worm. July, 1907.

PLATE X.

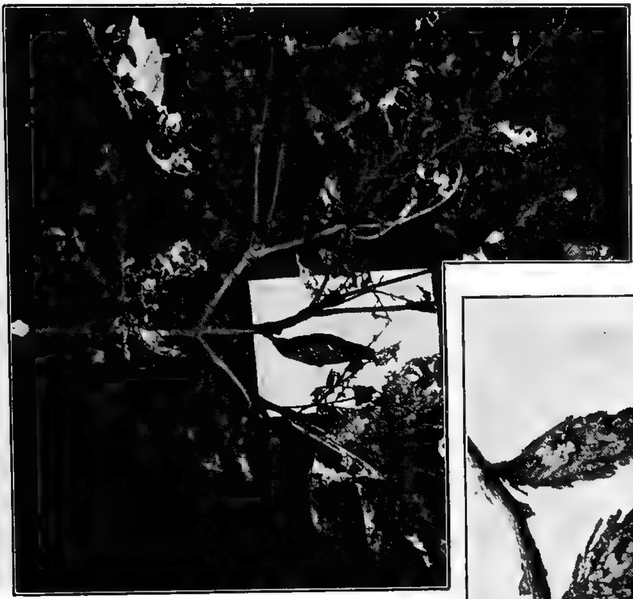


Fig. 2.

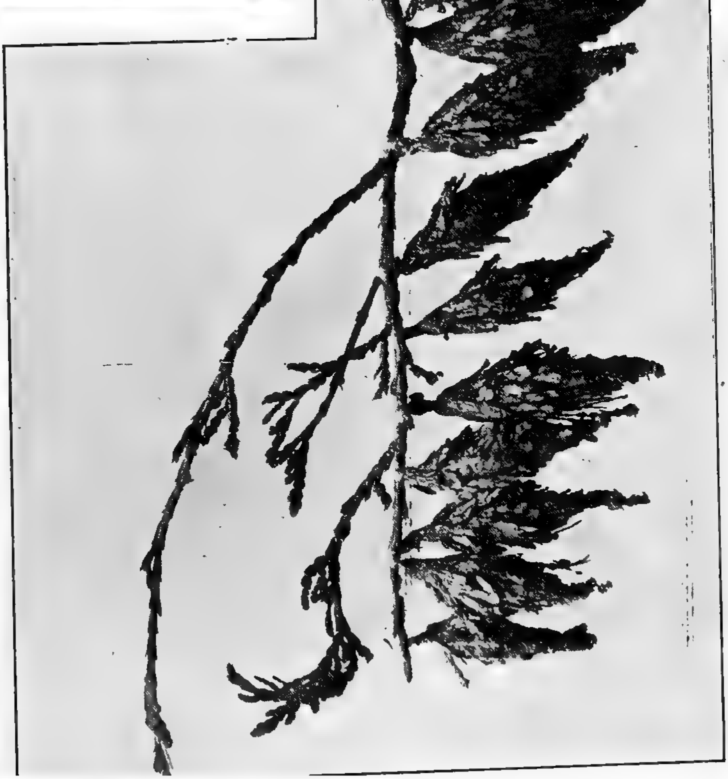


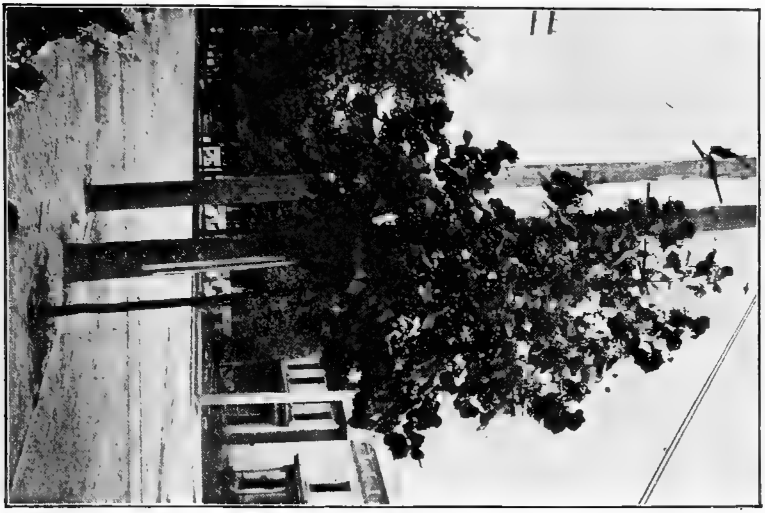
Fig. 1.

EXPLANATION OF PLATE XI.

Fig. 1. Sycamore injured by bag worm. Columbus, Ohio, July. 1907.

Fig. 2. Hard maple, Cincinnati, Ohio, injured by bag worm, July, 1907.

PLATE XI.



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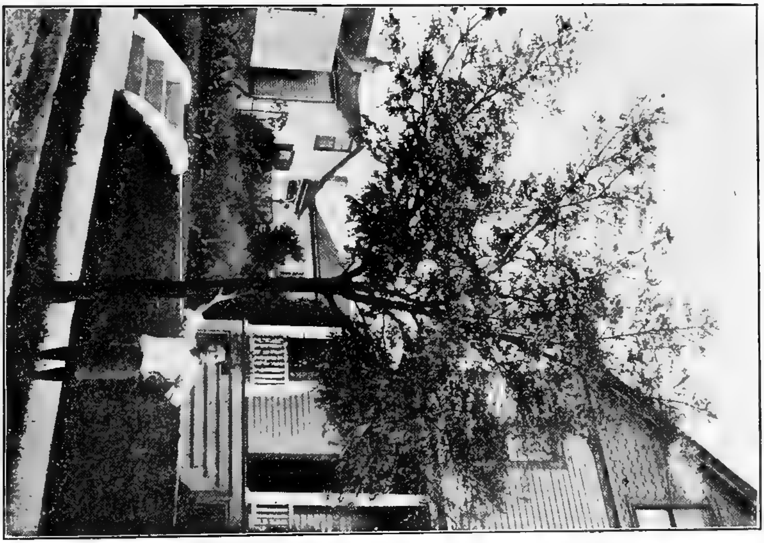
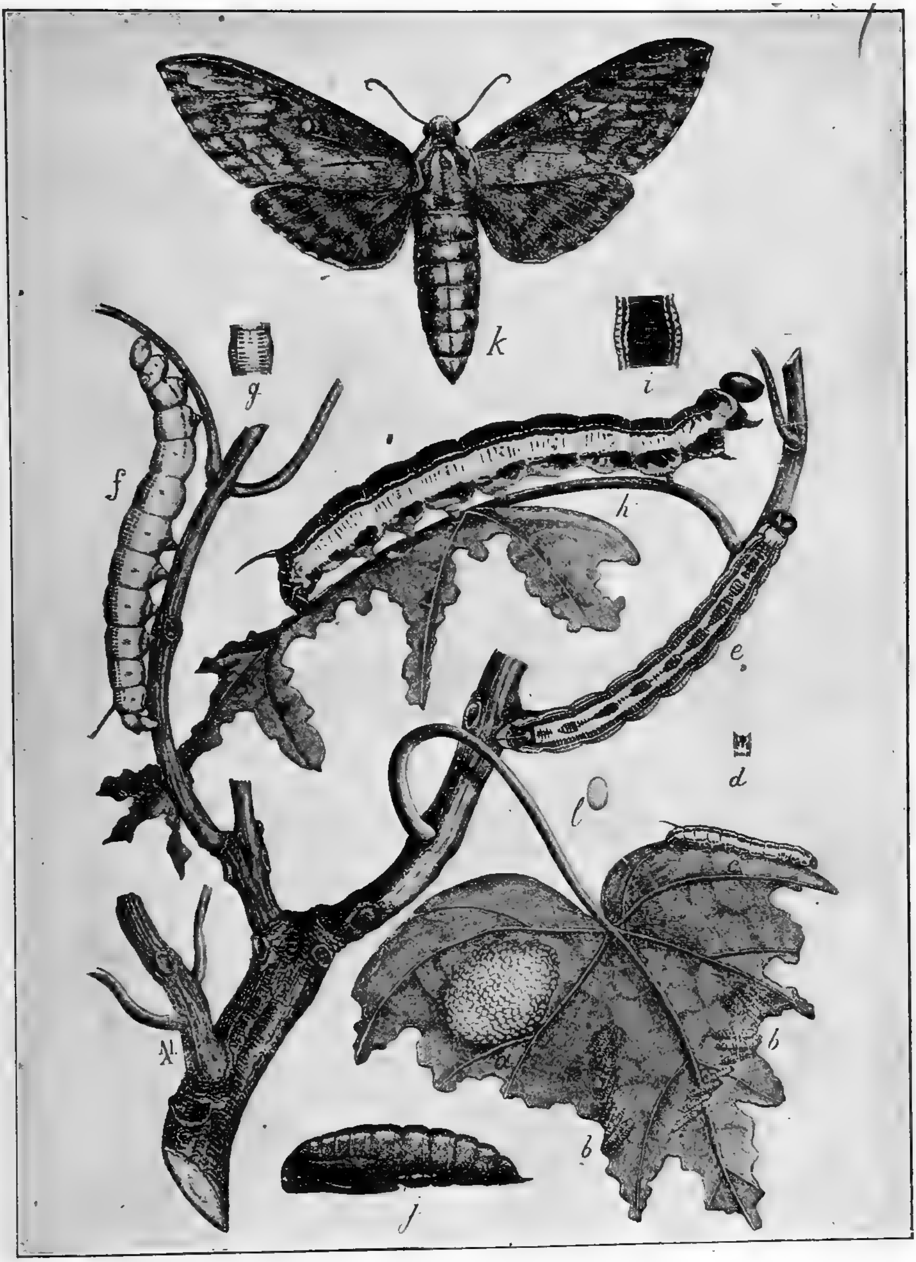


Fig. 2.

EXPLANATION OF PLATE XII.

The Catalpa Sphinx: a, egg-mass; b, newly-hatched larvae; c, a larva one-third grown; d, dorsal view of one its joints; e, f, h, differently marked larvae; g, dorsal view of one of the joints of f; i, do. of h; j, pupa; k, moth, natural size; l, egg enlarged. (From Riley, Rept. U. S. Commissioner of Agriculture, 1881.)

PLATE XII

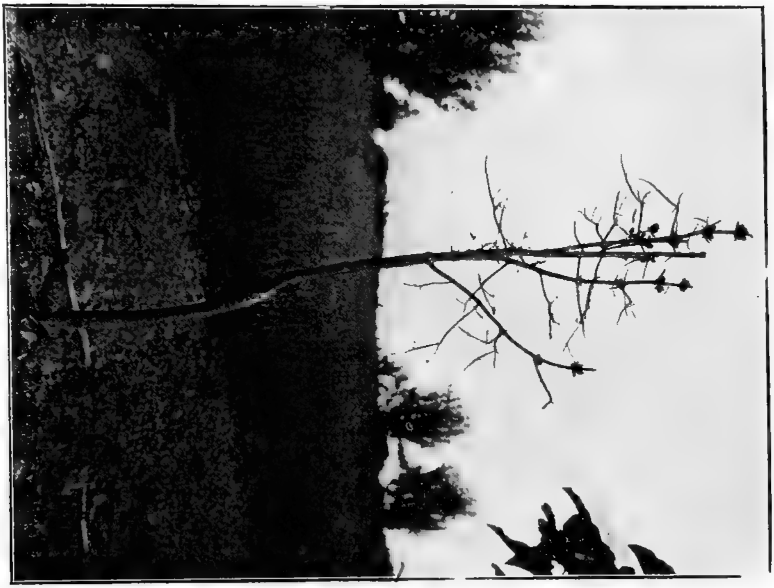


EXPLANATION OF PLATE XIII.

Fig. 1. Young catalpa on the farm of Mr. Clymer, Chillicothe, Ohio, defoliated by Catalpa Sphinx July 2, 1906.

Fig. 2. A catalpa tree illustrating the characteristic stunted growth following the successive injuries to the tips of the twigs by the Catalpa Bud Gnat.

PLATE XIII.



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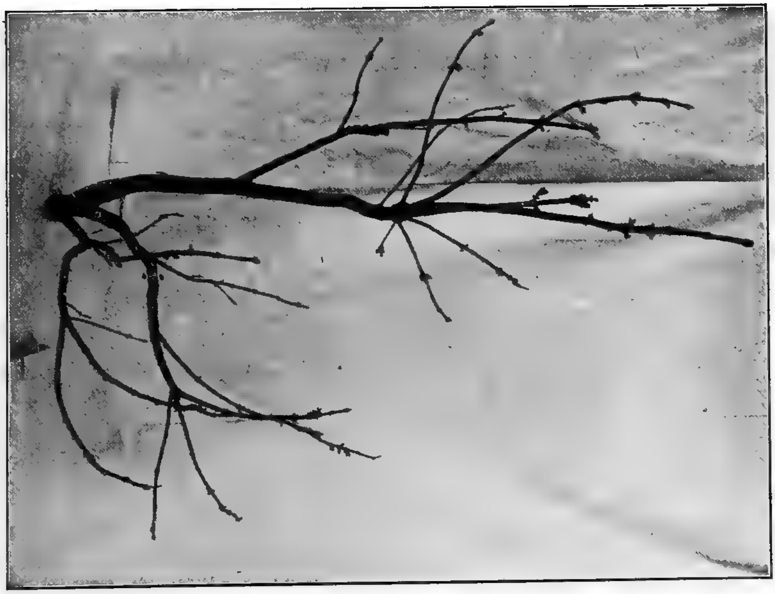


Fig. 2.

EXPLANATION OF PLATE XIV.

The top of a young catalpa tree illustrating the characteristic bushy growth which follows injury by the Catalpa Bud Gnat to the growing tip.

PLATE XIV.

EXPLANATION OF PLATE XV.

Fig. 1. Elm leaves injured by the Elm Leaf Beetle.

Fig. 2. Elm tree infested with the Elm Leaf Beetle during the season of 1906. The tree was banded with burlap and tanglefoot and the larvae collected and destroyed at frequent intervals. Photographed July, 1907.

PLATE XV.

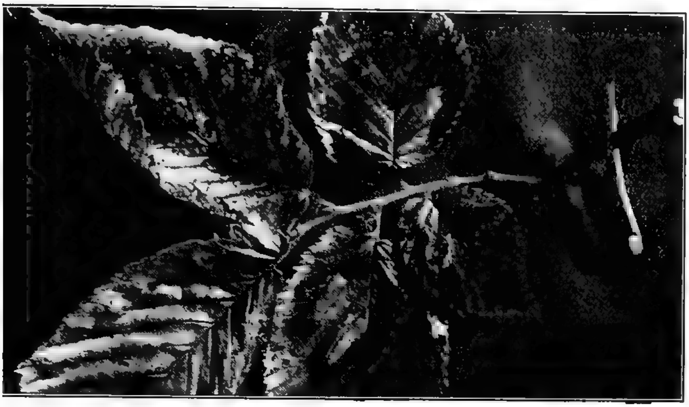


Fig. 1

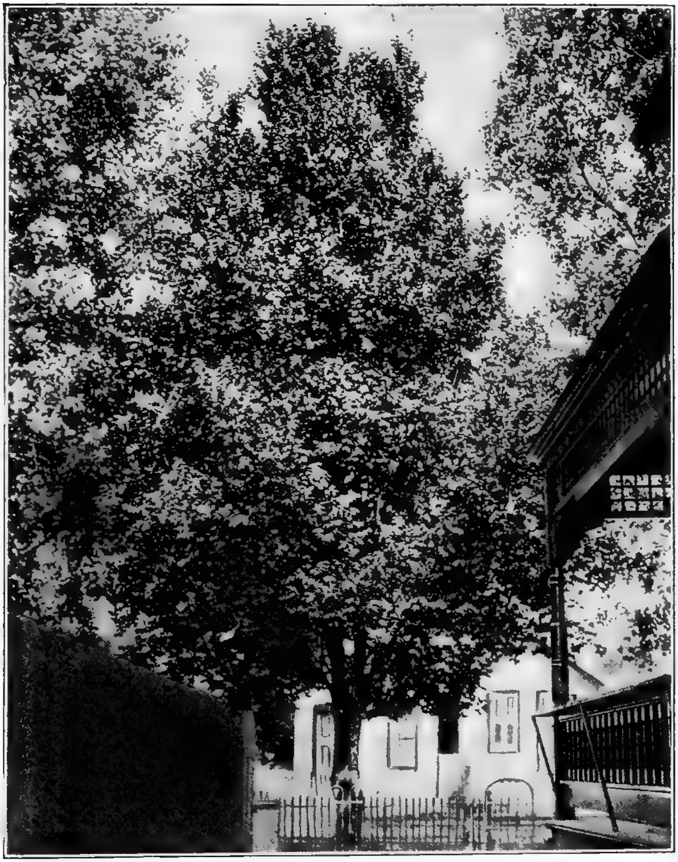


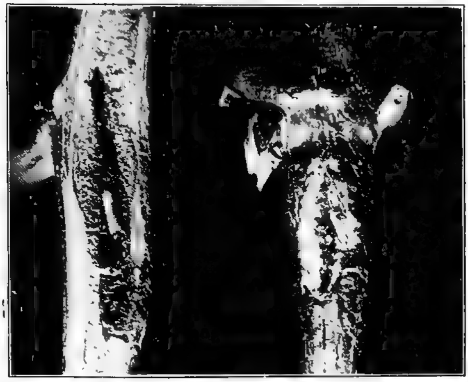
Fig. 2.

EXPLANATION OF PLATE XVI.

Fig. 1. The Locust Twig Borer, showing larvae in boring, and the characteristic swollen twig.

Fig. 2. Larva of the Locust Borer in the body of a young locust tree.

PLATE XVI.



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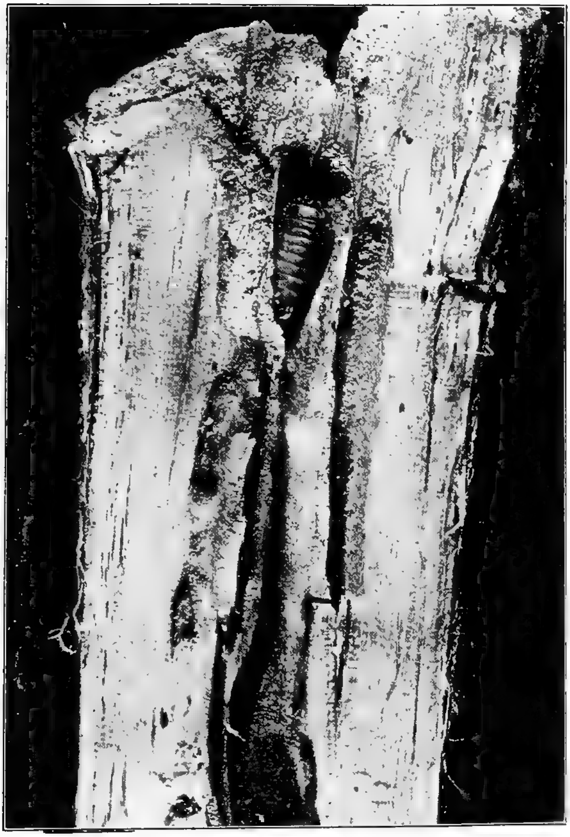


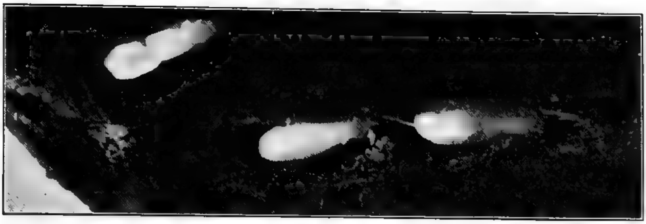
Fig. 2.

EXPLANATION OF PLATE XVII.

Fig. 1. Eggs of Locust Borer, much enlarged.

Fig. 2. Young locust tree injured by the Locust Borer, and subsequently broken by the wind.

PLATE XVII.



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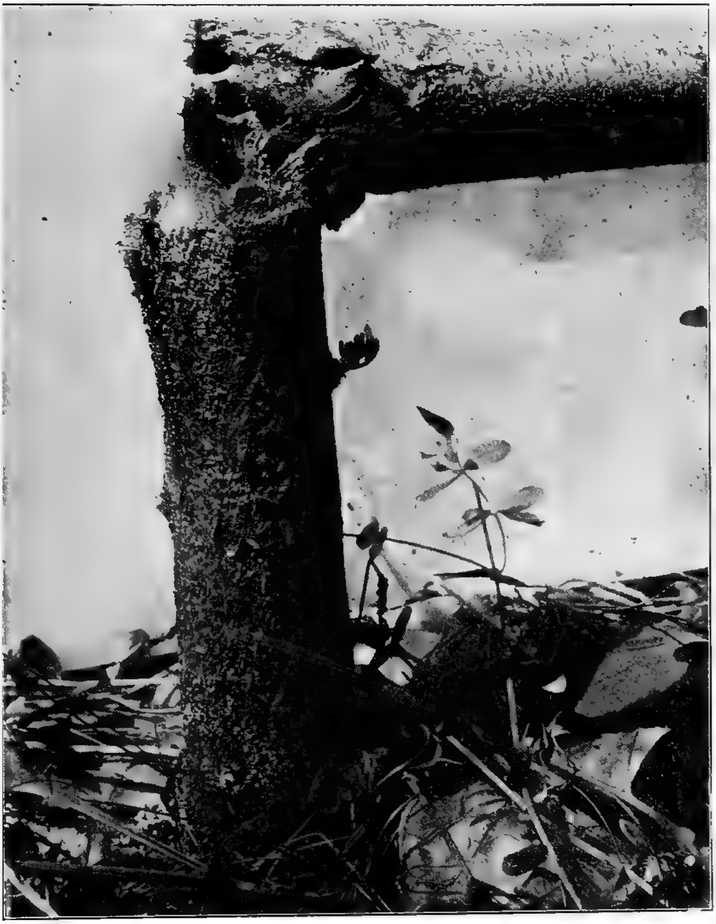


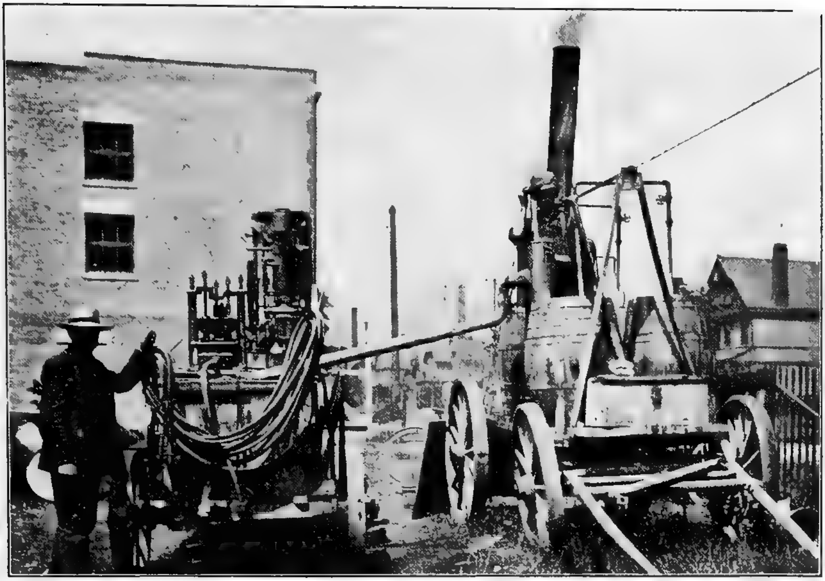
Fig. 2.

EXPLANATION OF PLATE XVIII.

Fig. 1. Preparing kerosene emulsion by the use of a steam boiling plant, capable of preparing 3000 to 4000 gallons of first-class emulsion per day.

Fig, 2. Same rig as above, being used for boiling lime sulfur wash. Used by the Department of Forestry, Cleveland, Ohio.

PLATE XVIII.



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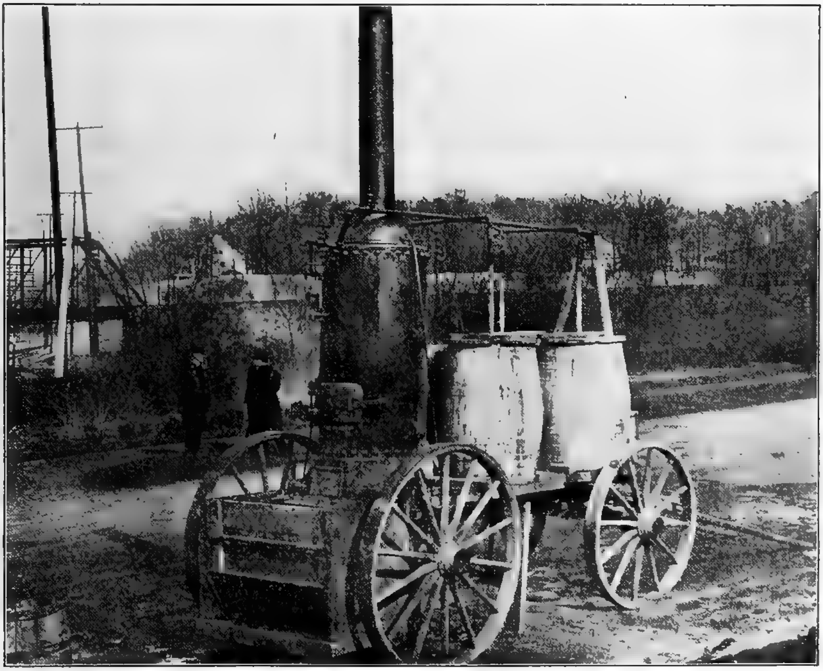
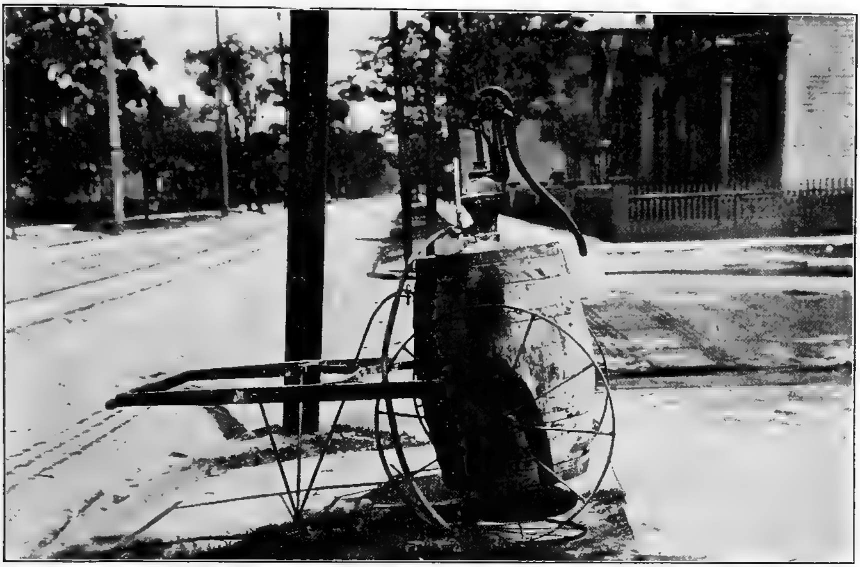


Fig. 2.

EXPLANATION OF PLATE XIX.

Figs. 1 and 2. Hand sprayers used by the Department of Forestry, Cleveland, Ohio, Fig. 2 represents a most excellent rig, durable, easily portable and capable of furnishing good pressure.

PLATE XIX.



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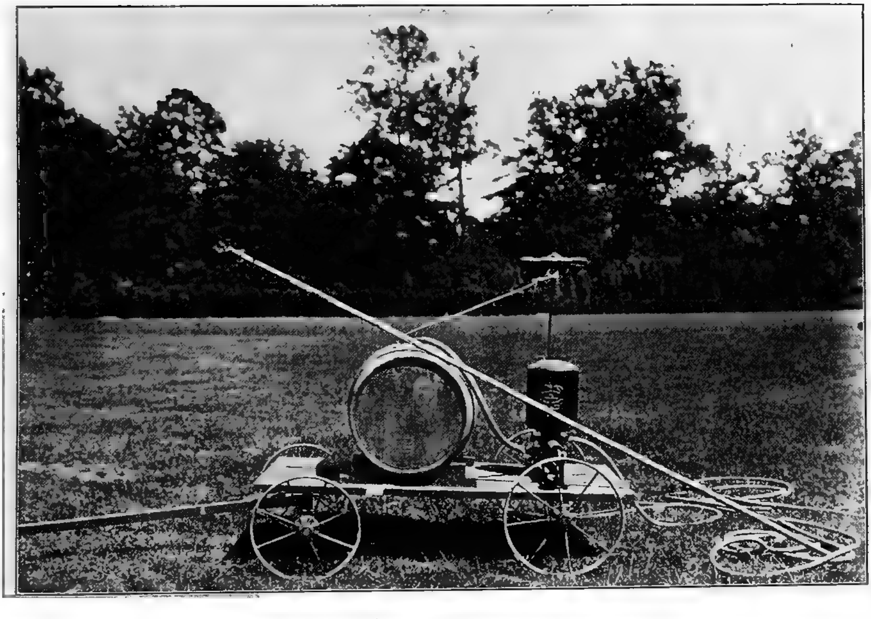

Fig. 2.

EXPLANATION OF PLATE XX.

Power sprayers used by the Department of Forestry, Cleveland, Ohio. Fig. 2 is the better of the two rigs.

PLATE XX.

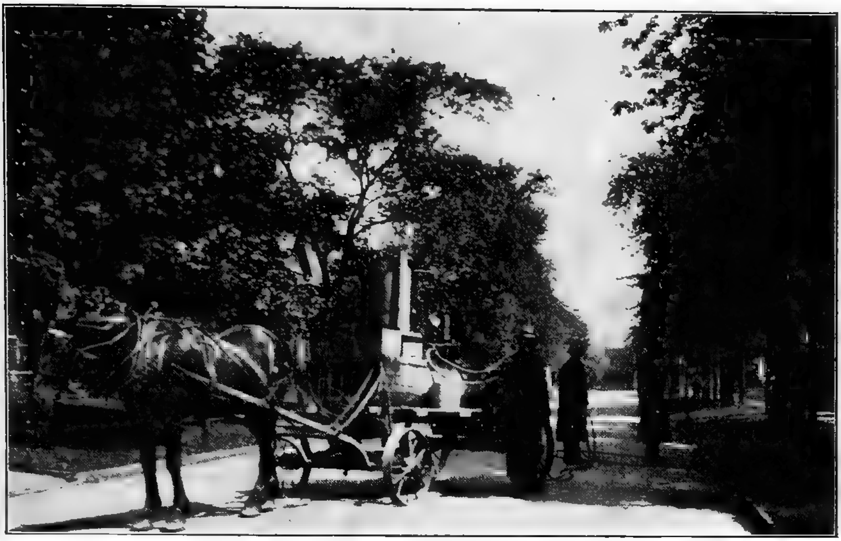

Fig. 1.

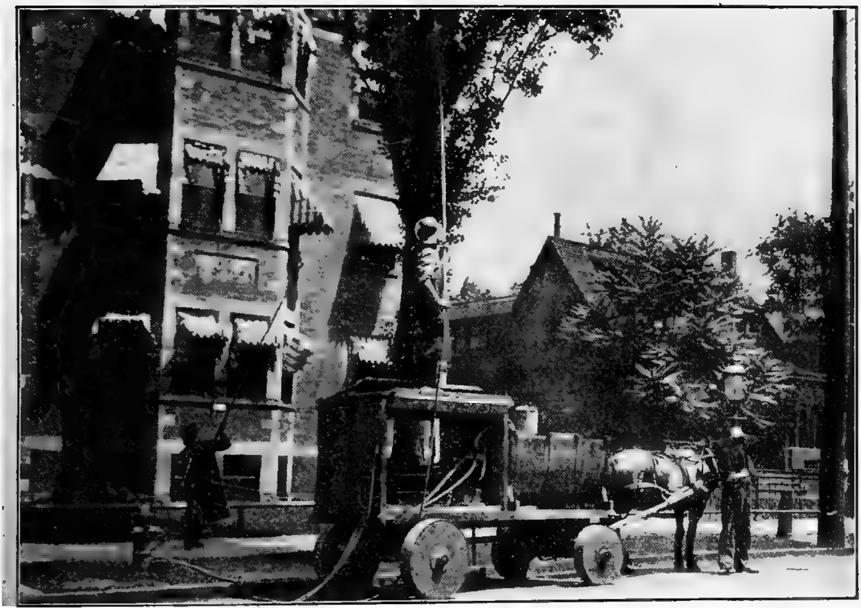

Fig. 2.

EXPLANATION OF PLATE XXI.

Fig. 1. An elm tree, Cleveland. Ohio, in bad condition, resulting likely from gas poisoning.

Fig: 2. An Ailanthus tree, Cincinnati, Ohio. The Ailanthus is a most excellent tree for street planting as it is almost immune from insect attack and thrives even though the roots are completely paved over as was the cáse of the tree illustrated. Smoke seems to have little effect upon this species.

PLATE XXI

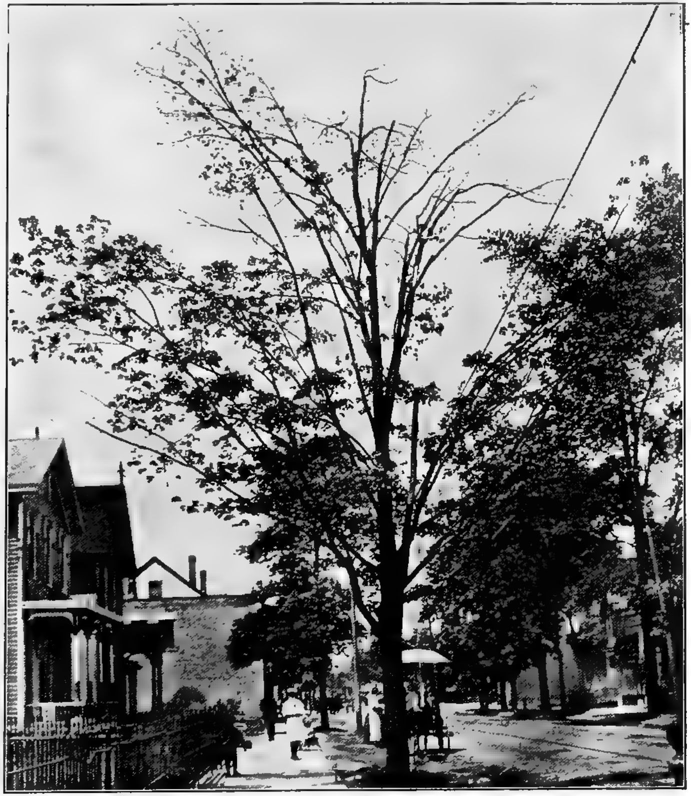

Fig. 1.

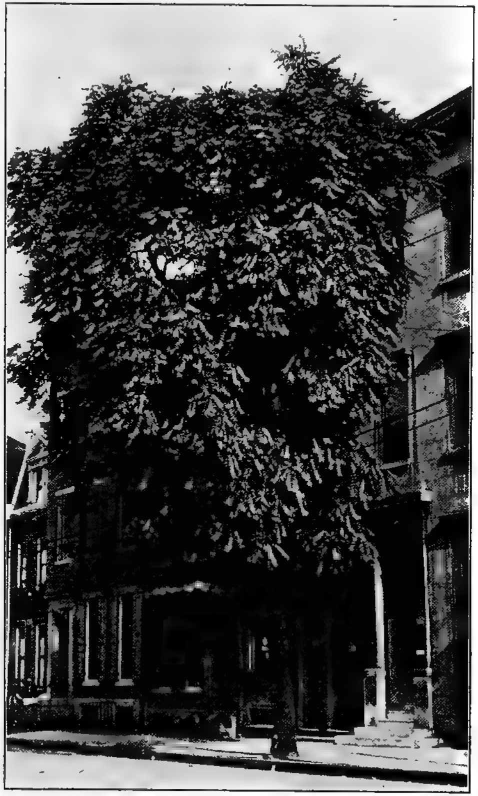

Fig. 2.

University of the State of New York

BULLETIN

OF THE

New York State Museum

FREDERICK J. H. MERRILL, *Director*

VOL. 6. No. 27.

May 1899

SHADE TREE PESTS

IN

NEW YORK STATE

By

EPHRAIM PORTER FELT, D. Sc.

State Entomologist

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UNIVERSITY OF THE STATE OF NEW YORK
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SHADE TREE PESTS IN NEW YORK STATE

The annual depredations of the white marked tussock moth, the severe injuries inflicted by the forest tent caterpillar not only on forest trees and sugar orchards but also on shade trees, the insidious work of wood and bark borers and the extreme destructiveness of the elm leaf beetle, have all combined to emphasize the vital importance of protecting shade trees in the cities and villages of this state.

Injuries to trees. Some idea of the destructive powers of shade tree pests may be gained by examining their past history. Albany and Troy have each lost over a thousand magnificent trees in the last five years through the work of the elm leaf beetle and its associates. The elms were not only defoliated once, but a second crop of leaves was frequently stripped from the trees, thus causing speedy death. About nine years ago thousands of trees were killed in Brooklyn, N. Y., by the maple tree scale insect, and last year it was so abundant as to inflict much damage in many localities. The white marked tussock moth yearly defoliates many valuable trees, in spite of the fact that a few well directed efforts would keep it in check. In most cases no effort is made to control the outbreak of an insect till it has about passed the remedial stage. That is, the insect has nearly completed its growth and therefore can not be poisoned through its food, or else the foliage is so completely devoured that there is very little to poison. Those interested in the welfare of trees, should be posted in regard to their principal insect enemies and be prepared to give their trees adequate protection.

Object of bulletin. The aim of this bulletin is to present in concise form the characteristics of the more destructive species attacking our principal shade trees, both through descriptions and figures, and to indicate methods of controlling them. If the insect does not agree with any of those described in the following pages, examples should be submitted to the state entomologist and the proper method of controlling it learned. In case of a very severe attack, it would probably be wiser to fight on general principles and ascertain more in regard to it later, for a host of caterpillars can cause irreparable damage in a few days if left alone. It is much easier to control insects than to subdue them after they have obtained a good start.

WHITE MARKED TUSSOCK MOTH

Notolophus leucostigma Sm. and Abb.

This species feeds readily on elm and maple leaves, displaying a special preference for those of horse chestnut and linden, and frequently does considerable damage. Last year it was a scourge in some cities of this state.

Characteristics. The caterpillar has a coral red head, a pair of long black plumes just over it, a single one at the opposite extremity of the body, four delicate yellowish or white brush-like tufts on the back, and just behind them, separated only by a segment, two small, retractile, red elevations. Along the back, except for the tubercles and tufts, there is a broad black band bordered by yellowish tubercles. A black line indicates the position of the spiracles or breathing pores, and below this latter line it is yellow, the legs being paler (fig. 1, *a*). This gives the general appearance of the caterpillar when it is half or two thirds grown, and at a time when its depredations begin to be apparent. The recently hatched larva is a pale yellowish or whitish creature with long, irregular hairs. As it feeds, increases in size and casts its skin from time to time, one after another of the characteristics of the full grown larva are assumed.

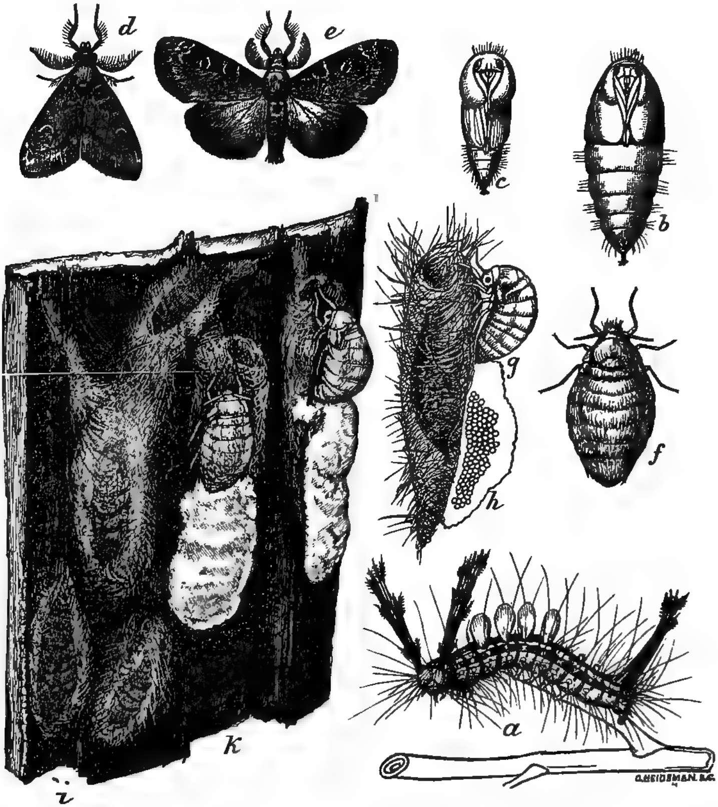

Fig. 1 White marked tussock moth. *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths laying eggs—all slightly enlarged (after Howard [Division entomology], U. S. Dep't agriculture, year book, 1895).

When maturity is reached, the larvae spin their thin cocoons in the crevices of the bark (fig. 1, *i*), interweaving their long hairs, and within this shelter transform to yellowish white pupae more or less shaded with dark brown or black (fig. 1, *b*, *c*).

The difference between the sexes is strikingly shown by comparing in figure 1, *d* and *e*, illustrations of the male, with *f*, that of the female. The former is a beautiful moth with large feathery antennae, the legs tufted, and the wings and body delicately marked with several shades of gray and grayish white. On the other hand the female is a nearly uniform gray, with simple antennae and but rudimentary wings.

After remaining from 10 to 15 days in the pupa state, the wingless female emerges and deposits her eggs on the empty cocoon under a conspicuous white mass of frothy matter (fig. 1, *h*, *k*), which soon hardens and forms a very effective protection. The individual egg is nearly spheric, about $\frac{1}{25}$ in. in diameter, white or yellowish white, and with a light brown spot surrounded by a ring of the same color.

Life history. The winter is passed in the egg state, the young, emerging about the latter part of May in this latitude, feed on the under side of the leaves at first and complete their growth in about a month, the transformation to the pupa state occurring the latter part of June and early in July. In Albany there is normally but one annual generation, but in New York city and vicinity there are two broods each season.

Remedies. The simplest and most satisfactory remedy is found in gathering and destroying the egg masses. As the eggs are in a compact mass, which is conspicuous and readily torn from the supporting cocoon, either by hand or by some form of a scraper, the task is quickly and easily performed. On account of the females being wingless, a tree once thoroughly cleaned will not become reinfested very soon if larvae are not abundant near by, and even then a band of loose cotton bound tightly around the trunk will prevent their ascending and a consequent reinfestation. This band is of value only when the tree is clean, and has not the slightest effect on caterpillars already in the trees unless they are shaken down. Only the eggs should be collected and destroyed, otherwise many beneficial parasites would be killed in cocoons not bearing egg masses. The egg masses may be collected any time after their deposition in the summer and prior to their hatching in the spring. The best time is in early spring just before the leaves appear, as this gives an opportunity for parasites to escape before the cocoons are touched and the absence of leaves facilitates the detection of the egg masses. In Rochester, N. Y., prizes were offered in 1894 to the school children gathering the largest number of egg masses with most excellent results. In cities and villages where this insect is the only important enemy of shade trees, this system or the payment of a bounty on eggs collected would undoubtedly result in the pest being kept in subjection at a comparatively small outlay. It may also be controlled by spraying, which will be discussed under a separate heading.

ELM LEAF BEETLE

Galerucella luteola Müll.

Along the Hudson river valley as far north as Troy, this insect is the worst enemy of the elms, specially the European forms, though under certain conditions it may inflict much injury on the American elms. So far as known, this pest has not made its way to any great distance from the Hudson river in this state, excepting on Long Island.

Characteristics. The elm leaf beetle is about $\frac{1}{4}$ inch long with the head, thorax and margins of the wing covers a reddish yellow. The coal black eyes and median spot of the same color on the head are prominent. Its other black and yellowish or yellowish green markings may be made out by aid of figure 2, plate 1. They are usually constant in the adult, but the colors are quite variable during life and change more or less after death. In some beetles emerging from winter quarters, the conspicuous greenish yellow stripes of the wing covers are nearly black. In the early spring the beetles are found in houses, sheds and other shelters where they pass the winter. On the appearance of the foliage, from about the first to the middle of May, the beetles fly to the trees and, after eating roundish holes (pl. 2, fig. 1) for some time, deposit their yellowish eggs in irregular rows side by side, forming clusters of from 5 to 26 or more (pl. 1, fig. 3), over half the total number of eggs laid being deposited between about the 10th and 20th day after oviposition begins, comparatively few being laid from the 20th to the 30th days.

The young grubs (pl. 1, fig. 4), about $\frac{1}{20}$ inch long and well provided with black tubercles and rather long hairs of the same color, appear early in June and feed only on the under surface of the leaves (pl. 2, fig. 2). They complete their growth in from 15 to 20 days and the mature ones (pl. 1, fig. 5) may be recognized by the broad yellow stripe dorsally and a narrower stripe of the same color on each side, the yellow stripes being separated by broad dark bands thickly set with tubercles bearing short, dark colored hairs. The full grown larvae or grubs descend the trees and transform to orange yellow pupae (pl. 1, fig. 7) in the crevices of the larger limbs and trunks, and on the ground around the base of the trees, where they sometimes form layers nearly half an inch deep.. In such places they change to beetles in five or more days. Up to 1894 this was supposed to complete the life history of the insect in this latitude, but that year the late Dr Lintner discovered the presence of a second brood and subsequent observations have not only demonstrated this to be the rule but that under exceptional circumstances there may even be a partial third generation. The grubs of the second generation are destructive in August. The development of the first brood is governed to some extent by local conditions, and later in the summer there is considerable diversity even on trees of the same street. The bulk of the larvae may be pupating under some elms, while on others numerous eggs and young may be found. The various stages of this insect are passed so rapidly that close observation and a ready adaptation to conditions are necessary in attempting to control it.

Remedies. Since the beetles fly into the trees each spring, the application of bands of any substance around the trunk will not have the slightest effect in preventing attack. A band is of value only when it keeps an insect not already in the tree from ascending the trunk. Sticky fly paper has been placed around trees attacked by elm leaf beetles and many of the descending grubs were captured, but the number killed is but a drop in the bucket compared with the host that transform in safety above. The grubs may also be killed in large numbers as they lie in masses around the trunk. But even this can be considered as but a palliative measure, for a considerable proportion must escape, and as the beetles are so prolific (one may deposit over 600 eggs), it requires comparatively few to cause serious injury. Another so called remedy is plugging the afflicted trees with sulfur or other compound. The idea being to introduce into the trunk, where it will be taken up by the sap, some substance which will not injure the tree and yet kill the insects, or at least render the foliage distasteful to them. It is a plausible theory but has no foundation in fact. The only thoroughly satisfactory treatment for this insect is found in spraying the foliage with some arsenical compound. The method of doing this will be treated of more fully on following pages.

ELM BARK LOUSE

Gossyparia ulmi Geof.

Elms along the Hudson river are unfortunate in suffering from a bark louse, which, like the elm leaf beetle, is an imported insect and prefers European elms.

Characteristics. The affected trees are easily recognized in midsummer by their blackened appearance, which is caused by the growth of a fungus in the honey dew excreted by the bark louse and covering the foliage, limbs and ground beneath. In sunlight, minute drops of the secretion may be seen falling in showers from the clusters of insects, giving an idea of the drain this species must be upon the vitality of an elm. The limbs which have harbored this bark louse for a few years begin to die, the tree itself shows signs of weakness, and when it is attacked by both the elm leaf beetle and this bark louse, succumbs shortly.

The adult females are rather conspicuous and may be found on the under side of the smaller branches, frequently clustered in masses and appearing not unlike certain lichens (pl. 2, fig. 3). In June each is about $\frac{1}{10}$ inch long, oval in outline, with the extremities slightly pointed, and if crushed causes a reddish stain from the contained ova. The body is surrounded by a mass of white, woolly secretion and the segmentation is also indicated by the same substance. The minute yellow young make their appearance early in July and soon settle for a time on the greener twigs and along the principal veins of the leaves. In the autumn the back of the partly grown bark louse is covered with spiny processes secreting a white waxy matter. At this time most of the insects forsake the leaves and settle for the winter in crevices of the bark. In the early spring activity is resumed and the round of life completed.

Remedies. As this insect is one of the sucking forms, securing its nourishment through slender hair like mouth parts from the under-lying tissues of the bark, its food can not be poisoned and recourse must be had to contact insecticides, as will be explained later.

TENT CATERPILLARS

Clisiocampa disstria Hübn.: *Clisiocampa americana* Fabr.

Complaints are received each spring of injuries to maples and other shade trees by caterpillars. Examples submitted show that the offender is more frequently the forest tent caterpillar, though occasionally its near relative, the apple tree tent caterpillar, may be a partner in the mischief.

Characteristics. The caterpillars of the two species may be readily distinguished. The forest tent caterpillar has a blue head and a row of 10 silvery white spots down the back, as represented in figure 2. The apple tree tent caterpillar has a black head with a bluish white stripe along the back. The former spins its web against the bark of a tree and on this account its threads are frequently overlooked, while the conspicuous tents (fig. 3) of the latter are familiar objects in many orchards and in wild cherry trees along the roadside.

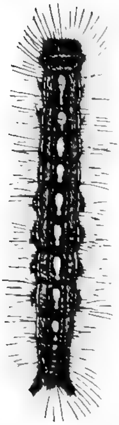

Fig. 2 Forest tent caterpillar (after Riley).

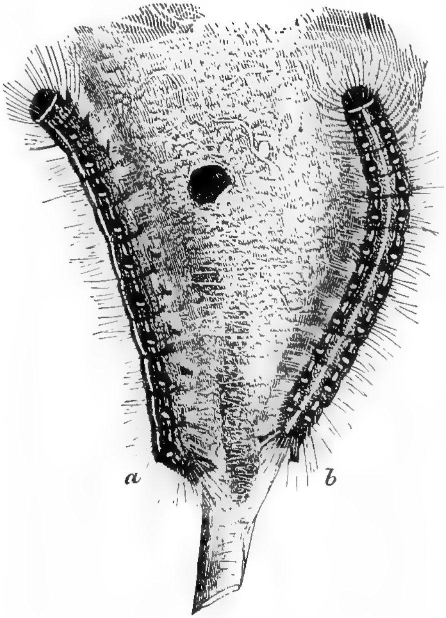

Fig. 3 Apple tree tent caterpillars and nest (after Riley).

Life history. The life histories of these two species are quite similar. The eggs which are deposited in broad belts in June or July around the smaller twigs, those of each species being easily distinguished from the other (see fig 4, 5), do not usually hatch till spring. The caterpillars appear early and feed most voraciously, the forest tent caterpillar completing its growth in June or the first of July, while the other matures a little earlier. The moths emerge the latter half of June or the first half of July and deposit their eggs from which caterpillars come another spring.

Remedies. The caterpillars of both of these species are very susceptible to arsenical poisons and can be readily controlled by spraying, as will be described later. In case the expense attendant upon this operation is too great, something may be done by jarring the caterpillars from the trees, first applying a broad sticky band, e. g., tar on thick building paper, tangle foot fly paper, etc., or a band of loose cotton around the trunk so as to prevent the dislodged enemy from ascending. The jarring can be performed best on a bright day when the caterpillars are feeding on the leaves, as they are then much more easily disturbed. Send a boy into the tree with a padded mallet with instructions to begin near the top and jar the depredators from the limbs. Those hanging persistently by long threads may be swept down with a pole. Kill the caterpillars as they assemble below the sticky band in order to guard against their bridging it when present in numbers, and repeat the jarring at intervals of a day or two till the trees are comparatively free from the pests. The caterpillars of the white marked tussock moth can also be treated in this manner. Many forest tent caterpillars can be killed by spraying with kerosene emulsion when they assemble in large masses on the lower limbs and trunks for the purpose of molting. At this time, they may also be brushed down or forced to drop by the judicious use of a torch. Apple tree tent caterpillars, on account of their remaining during damp or cold weather in their webs, can easily be removed and destroyed at these times.

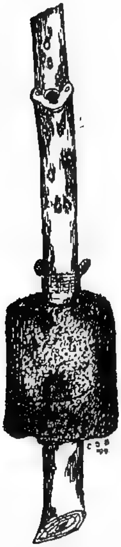

Fig. 4 Egg belt of forest tent caterpillar, showing a few exposed eggs, enlarged.

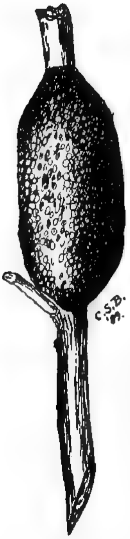

Fig. 5 Egg belt of apple tent caterpillar, enlarged.

FALL WEB WORM

Hyphantria cunea Drury

During the latter part of August in this latitude, conspicuous webs are frequently seen inclosing the tips of branches of many trees, each web containing brown skeletonized leaves. This is the work of the fall web worm and may be easily distinguished from that of the apple tree tent caterpillar not only because they occur later in the season but the tips of the branches are inclosed and the caterpillars feed within the webs, while those of the common apple tree species use the web only as a retreat when not feeding.

Remedies. These gregarious caterpillars are easily destroyed within the web by removing and burning the infested portion of the limb. They can also be controlled by the use of poisons.

BORERS IN TRUNK AND LIMBS

There are several very injurious borers infesting the trunks and branches of elm and maple trees, and since they work under the bark or within the wood, it is extremely difficult to control them.

Indications of attack. The presence of these insidious enemies is usually indicated by one or more dead branches and a more or less sickly appearance of the tree. Borings or "saw dust" may be found around the base of the tree in some instances, and in bad attacks large patches of loose bark may be found. On removing or cutting into the bark, the familiar work of borers is exposed (pl. 3, fig. 3), and the white, usually legless, somewhat flattened grubs may be seen lying in their burrows.

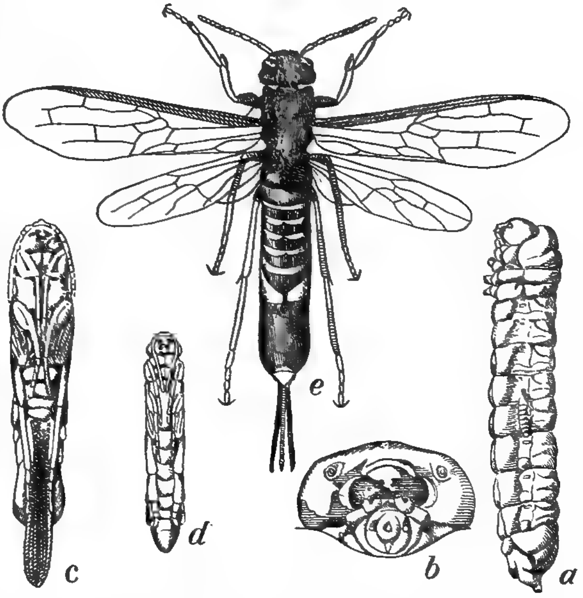

Fig. 6. Pigeon Tremex; *a*, larva showing the Thalessa larva fastened to its side; *b*, head of larva; *c*, pupa of female; *d*, male pupa; *e*, adult female—all slightly enlarged.

Elm and maple borers. The parent of the maple tree borer, *Plagionotus speciosus* Say, is a handsome black beetle with yellow markings and is represented on plate 3, figure 1. The adult of the more common of the elm tree borers, *Saperda tridentata* Oliv., is a slaty colored beetle with dull reddish markings and is represented on plate 3, figure 2. The thick fleshy grubs of several curculios or weevils are sometimes found in numbers just beneath the bark of elms and occasionally cause considerable injury.

Pigeon Tremex. The larva of another insect known as the pigeon Tremex, *Tremex columba* Linn., or horn tail, runs large burrows through the wood of elms and other trees, specially those which have been weakened by the attack of some other insect. Its various stages are represented in figure 6. The female is a magnificent brown insect with yellowish markings and is occasionally found attached to a tree by its inserted ovipositor.

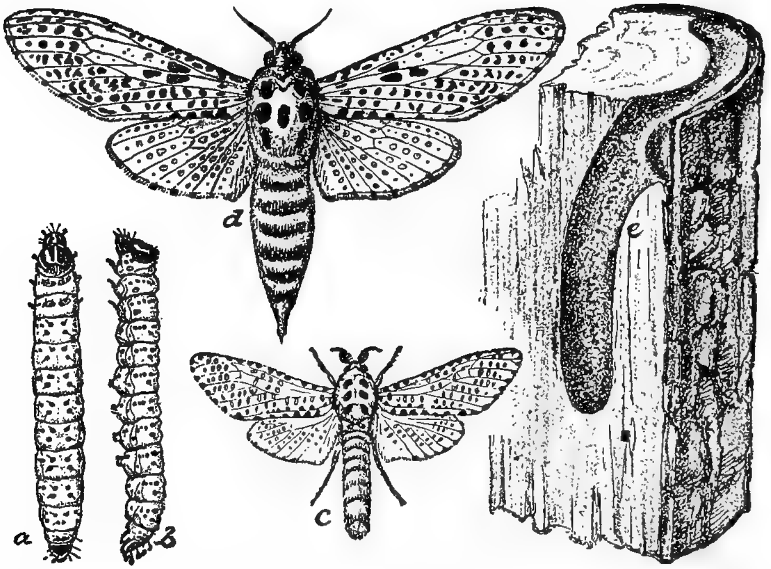

Fig. 7 Leopard moth: *a*, *b*, dorsal and lateral aspects of caterpillar; *c*, *d*, male and female moths; *e*, burrow of caterpillar (after Pike).

Leopard moth. In the vicinity of New York city there is another borer very injurious to elms and maples. It is the caterpillar of the leopard moth, *Zeuzera pyrina* Fabr., a species which has recently made its way to our shores and is proving a serious pest. This insect and its work may be recognized by the accompanying illustration, the moth being white marked with black.

Remedies. One of the best preventives of borers is to maintain the trees in a flourishing condition. The prompt removal and destruction, in order that no insects may escape to propagate their kind, of infested trees or limbs will do much to keep these pests under control, and in the case of those suffering from a severe attack, is almost the only remedy. The handsome beetles of the maple tree borer are abroad during June, July and August, their eggs being deposited the latter two months. The adults of the elm borer may be found during May and June, the eggs being laid the latter month. If the attack has not proceeded too far and the trees are of sufficient value, a considerable degree of protection will probably be obtained by coating the trunk of the maple and the trunk and larger limbs of the elm with a solution of soft soap and carbolic acid during the period these beetles deposit eggs, thus preventing further infestation. This solution may be applied either as a spray or with brushes and should be renewed as often as washed off by rains during the period of oviposition. In the case of more valuable trees, specially those infested with the fleshy grubs of curculios or weevils, it may pay in some instances to shave away the bark over the infested portions, till living tissues are reached, and kill the borers by the application of kerosene emulsion, and then protect the treated areas from drying by applying a coating of some thick, adhesive substance, e. g. a mixture of cow dung and lime, grafting wax or other substance. Experiments conducted in France have shown that much more of the bark may be removed, even strips two inches wide, and the trees not only recovered but the borers were killed by the vigorous growth made in the effort to heal the wounds. In case of very severe attacks, this would certainly be worth trying. The best results would probably be obtained if the operation was performed in the spring. The pigeon Tremex works so deeply in the wood, that little can be done to arrest its attack, but fortunately it infests only sickly trees, as a rule, and therefore simply aids in the final destruction of a tree.

Serious injury by the leopard moth can only be prevented, in regions where it occurs, by constant watchfulness. Indications of its presence should lead to immediate examination and the digging out of the borer or the destruction of the infested limb. Some of the more valuable trees in the parks of New York city are protected from this pest by killing the caterpillars in their burrows with a wire and when this is not possible, resort is had to carbon bisulfid, which is injected into the burrow by the aid of a long nosed oil can and the opening is then closed with putty.

COTTONY MAPLE TREE SCALE INSECT

Pulvinaria innumerabilis Rathv.

Maples and occasionally elms suffer severely at times from the attacks of this scale insect. A few full grown individuals are represented in the accompanying figure. The insect may be recognized by its brownish scale at one end of a large white cottony mass. In bad attacks, the insects may form festoons along the under side of the smaller limbs.

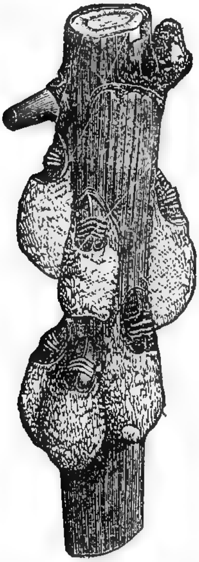

Fig. 8 Cottony maple tree scale insect.

Remedies. Like the elm bark louse this species obtains its food by suction from the underlying tissues and therefore can not be poisoned. The cottony mass covering the body of the female protects her from contact insecticides, consequently little can be done till the unprotected young appear in July, when spraying with kerosene emulsion or whale oil soap solution will be found most effective.

VALUE OF OUR NATIVE BIRDS

The valuable services rendered by our native birds should be more generally recognized. It is a matter of record that after the introduction of the English sparrow, most of our native birds were driven from the cities and that the tussock moth caterpillars, previously hardly noticed as pests, became destructive. It is very true that prior to the introduction of the English sparrow, a measuring worm had been a pest in various cities, but this is an additional proof of the effect birds may have upon insect life. In the same way there are a number of birds known to prey on the tent caterpillars and were these friends of man accorded the protection and encouragement they deserve, instead of being hunted and driven away, it is very probable that the ravages of these pests would be much less severe than at present. Robins, orioles, chipping sparrows, cat birds, cuckoos, the red eyed, white eyed and warbling vireos, cedar birds and nuthatches have been observed feeding on forest tent caterpillars by Miss Soule. "The nuthatches would stand by a patch of larvae lying close together below a tar band on a tree and eat so voraciously and with such an entire abandonment of self-consciousness that I could go close and put my hand on them before they would fly. This experience was repeated several times."[a] The value of birds in keeping other pests under control is also strikingly shown in the experiment conducted by Mr E. H. Forbush, ornithologist of the Massachusetts board of agriculture. In a typical orchard at Medford, Mass., a little trouble was taken to attract the native birds, the nests of the English or house sparrow being destroyed. The results were greatly in favor of protecting our indigenous forms. In the neighboring orchards it was evident that canker worms and tent caterpillars were very numerous, but in the orchard in question, the trees were seriously injured in only one or two instances, though no attempt was made to control the insects by spraying or other artificial means.

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[a] Weed, C. M. New Hampshire agricultural experiment station. Bulletin 64. April 1899 (cites and quotes Miss Soule).

Our native birds are undoubtedly of great value and will richly repay any slight effort that may be made for the purpose of attracting them to a locality. Winter birds may be induced to remain in a neighborhood by hanging in the trees pieces of meat or partially picked bones, and will spend much time in searching out and devouring numerous insects and their eggs, relying on the meat only when conditions are unfavorable for obtaining insect foot. Migratory birds may be induced to remain in larger numbers in a locality by providing them with suitable nesting places and materials, and by protecting them from cats and cruel boys. Thickets in the vicinity will afford shelter for certain species and if a few mulberry trees are set out, their fruit will serve to protect cherries, as the birds are said to eat the mulberries by preference. Most of these suggestions are taken from a very practical paper by Mr Forbush.

SPRAYING TREES

Though it is rather costly to spray trees in a thorough manner, in the case of the elm leaf beetle at least, it is much more satisfactory than any other method of fighting the pest and possesses the additional advantage of also controlling other leaf feeding species.

Rules for spraying. Apply the poisonous mixture at the time the insects begin to feed and on the part of the tree eaten. To control the elm leaf beetle it is best to spray once after the leaves have partly unfolded in order to kill the beetles before they can deposit many eggs, and a second time early in June for the purpose of destroying the grubs hatching from eggs laid by stray beetles. The second spraying must be on the under surface of the leaves because the grubs eat only the more tender under portions. They grow so rapidly and their development is affected to so great an extent by local conditions that the proper time for treatment must be determined largely by observation. If the eggs of the white marked tussock moth have not been removed, as advised on a preceding page, the caterpillars can be destroyed by spraying the latter part of May or early in June, and, as in the case of the elm leaf beetle, it is advisable to throw the poison on the under surface of the leaves, since the very young caterpillars rarely break the upper epidermis. The same treatment is also very effective in the case of tent caterpillars, and in each case will be found valuable in proportion to its thoroughness. The aim of the operator should be to cover every leaf evenly with a mist like coating of the poisonous mixture. Spray till the leaves begin to drip but no more.

Proper apparatus. In order to do this work successfully one must possess a force pump capable of throwing a stream some distance, a number of feet of hose and a nozzle which will discharge a rather fine spray. There must also be something to hold the poisonous mixture, while a ladder facilitates the work greatly.

One of the best arrangements for hand work is most probably found in the spraying outfit mounted on wheels, so that it can be readily moved from place to place (plate 4). In most cases this takes the form of a box or barrel to which a force pump is firmly attached, and either provided with wheels or else designed to be placed in a wagon. In spraying tall trees 25 to 50 or more feet of ¼ or ½ inch hose should be provided, while the addition of a brass or iron and brass extension 10 to 25 feet long adds materially to the value of the apparatus. It is also necessary to have a good nozzle which will not clog, but will produce a fine spray and which can be quickly adjusted to throw a coarse spray some distance if necessary. Such an outfit is of great service to any individual having considerable spraying to be done and undoubtedly it could be used to advantage by those desiring to make a business of spraying in a small way, as for example the treating of trees here and there for those in cities desiring their trees sprayed and not willing to purchase the necessary apparatus.

In the extended work against this insect conducted by cities and villages, it is desirable to have apparatus that will admit of more rapid work. This has led to the refitting of retired fire engines and the designing of more or less cumbersome outfits for this purpose. In all cases these makeshifts have been successful, though they are not so satisfactory in operation as those specially fitted for the purpose. Probably the best apparatus yet designed for spraying trees is that constructed under the direction of Dr E. B. Southwick, entomologist of the department of public parks of the city of New York, which is the form used in Albany. The whole outfit is represented in plate 5. It consists of a "Daimler" gasoline motor operating a Gould force pump—the motor and pump weighing but 300 pounds can be placed in the bottom of a spring wagon along with the 100-gallon tank containing the poisonous mixture. This motor has the advantage of being almost noiseless in operation and is scarcely noticed by passing horses. It is very inexpensive to operate, as a gallon of gasoline is sufficient for a day and it requires little attention. The smallest size Gould 3-piston pump is the one used with the motor, though Dr Southwick now recommends a larger one in order to utilize the power more fully. This apparatus, with the tank, 400 ft. of ⅜ in. rubber hose and other necessary fittings, can be bought for $475. Other engines and pumps could undoubtedly be used and would give good results. This power can easily supply four lines of hose, though in Albany not more than two can be used to advantage in most places.

Mr P. C. Lewis, of Catskill, N. Y., who was in charge of the spraying in Albany in 1898, had several interesting devices for saving time and increasing the efficiency of the work. He designed a modified stepladder, about 16 feet high with platforms for two men and on two of its legs there are small wheels which permit ready removal from place to place. It is so constructed that it can be folded up and drawn behind the wagon when some distance is to be traversed. He also had in constant use a metal extension 25 feet long. The lower portion is composed of larger tubing, thus making it stiffer and at the same time rendering it easier to handle because the greater part of the weight is near the operator. This extremely long extension is suspended by a rope from the top of the modified stepladder in such a manner that the man has only to guide the stream. This arrangement does away with all climbing, as it was found impracticable to attempt to reach the tops of the taller trees. In many instances the huge steps could be placed in the middle of the street and the trees on both sides sprayed either from the steps or from the ground.

Arsenical compounds. These are effective against insects which devour portions of a plant and of value only when placed where they will be eaten. The following formulae are recommended:

Paris green	1 pound
Quicklime	1 pound
Water	100–300 gallons

London purple	1 pound
Quicklime	2–3 pounds
Water	100–300 gallons

The more common proportion is at the rate of 1 pound of the poison to 150 gallons of water, and less should be used on the more tender foliage like that of the peach or there may be serious injury. For the elm leaf beetle, use 1 pound of the poison to 100 gallons of water. The addition of lime is not necessary, specially with paris green, but is a wise precaution as it neutralizes any free arsenic acid and thus prevents burning of the foliage.

Another substance which has received high praise and may come into general use after its good qualities become better known, is the arsenate of lead. The value of this compound as an insecticide has been brought out by numerous experiments, made in the extensive work against the gypsy moth. One advantage is that it can be applied in very large quantities without injuring the foliage. When properly prepared, it remains for some time suspended in the water, imparting a milky color, and also adheres to the leaves much longer than either paris green or london purple, and it promises to be of special value against the elm leaf beetle on this account. Its whiteness is another advantage, because of which, it is readily detected upon green foliage.

In order to obtain the best results, the poison should be prepared just before using, by dissolving 11 ounces of acetate of lead (sugar of lead) in 4 quarts of water in a wooden pail, and 4 ounces of arsenate of soda (50%) in 2 quarts of water in another wooden pail. As the acetate or sugar of lead dissolves rather slowly in cold water, the process can be hastened by using warm water. The resulting solutions should then be poured into the spraying tank containing enough water to give the desired proportions. In most cases this will mean turning them into 100 or 150 gallons of water, or but 80 gallons of water when spraying for the elm leaf beetles, though some recommend a larger proportion of the poison, and the same amounts to 100 gallons will kill the grubs.

Contact insecticides. These are substances which kill insects by contact and affect only those individuals touched. They are used against the elm bark louse, the woolly scale of the maple and other sucking insects

Kerosene emulsion is one of the principal contact insecticides and is prepared by dissolving ½ pound of hard soap in 1 gallon of boiling water and while it is still hot add 2 gallons of kerosene and emulsify by passing it rapidly through a force pump and back into the vessel till it assumes a creamy consistency and oil does not rise to the surface. Dilute with 9 to 15 parts of water and spray the young lice as they appear in the summer. In limestone regions where hard water is the rule, better results will probably be obtained by using the sour milk emulsion, which is composed of 2 gallons of kerosene and 1 gallon of sour milk emulsified by churning or passing through a pump. A mechanical mixture of the two may be used, if desired, with machines now on the market for that purpose. Or a solution of 1 pound of whale oil soap to 4 gallons of water will be found effective. In the use of any of these compounds, thoroughness is of first importance. They may be sprayed on the insects, applied with brushes or in any other way that is convenient, provided the tree is not subjected to such drenching that the insecticide used will collect around the trunk and cause serious injury.

EXPLANATION OF PLATES

Plate 1

Fig. 1 Elm leaves showing eggs and work of young larvae.
Fig. 2 Elm leaf beetle (x2).
Fig. 3 Vertical and lateral view of eggs, very much enlarged.
Fig. 4 Young larva, very much enlarged.
Fig. 5 Full grown larva (x5).

Plate 2

Fig. 1 Leaf showing holes eaten by elm leaf beetle.
Fig. 2 Leaf skeletonized by elm leaf beetle grubs.
Fig. 3 Females of elm bark louse, slightly enlarged.

Plate 3

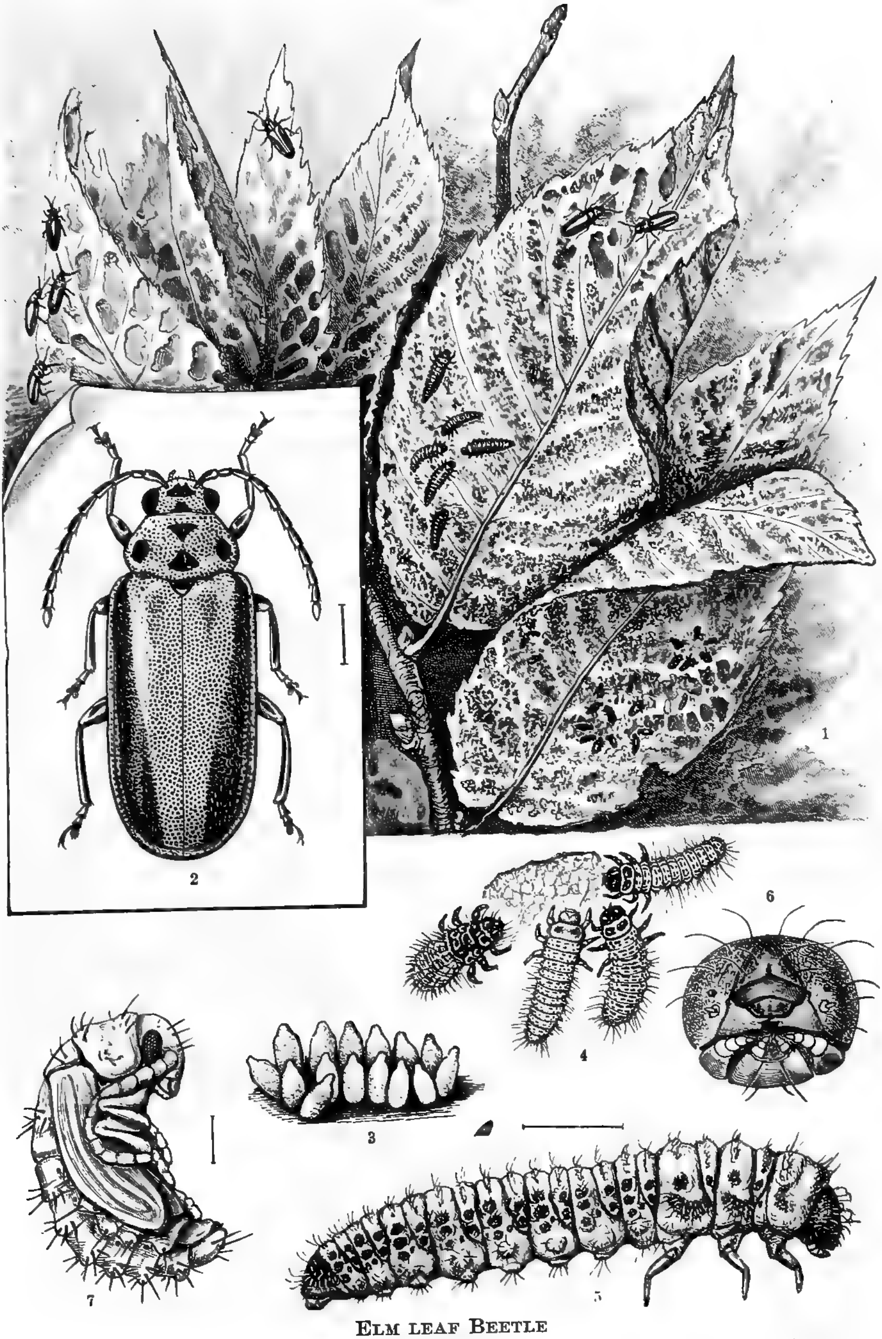
Fig. 1 Maple tree borer, *Plagionotus speciosus*.
Fig. 2 Elm borer, *Saperda tridentata*.
Fig. 3 Work of elm borers, *Saperda* and *Neoclytus*.

Plate 4

Hand spraying outfit in operation.

Plate 5

Power spraying outfit in operation.



Elm leaf Beetle
(After Howard [Division Entomology], U. S. Department agriculture,
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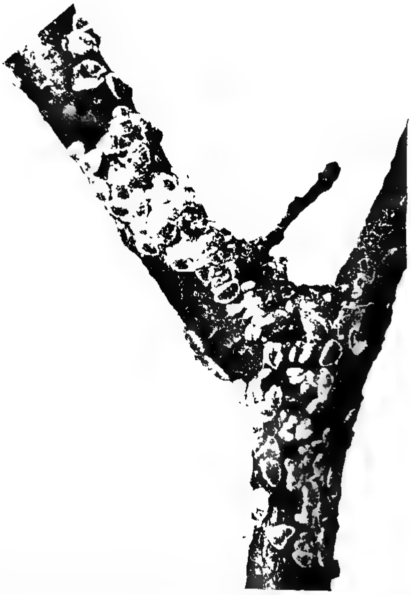


Fig. 3 Females of elm bark louse (slightly enlarged)

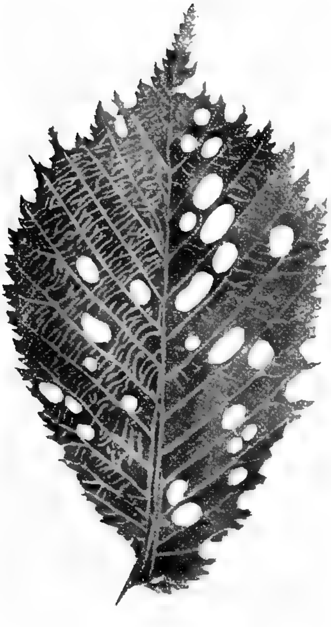


Fig. 1 Leaf showing holes eaten by elm leaf beetle

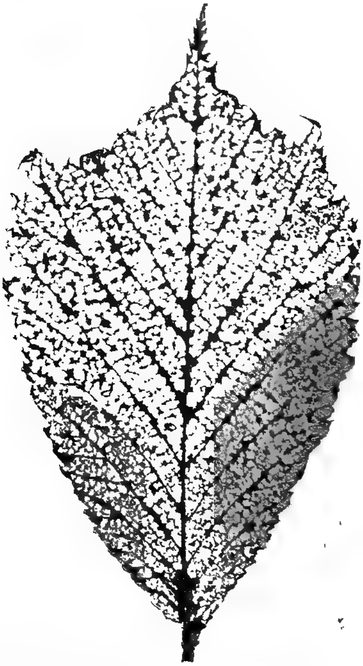


Fig. 2 Work of elm leaf beetle larvae

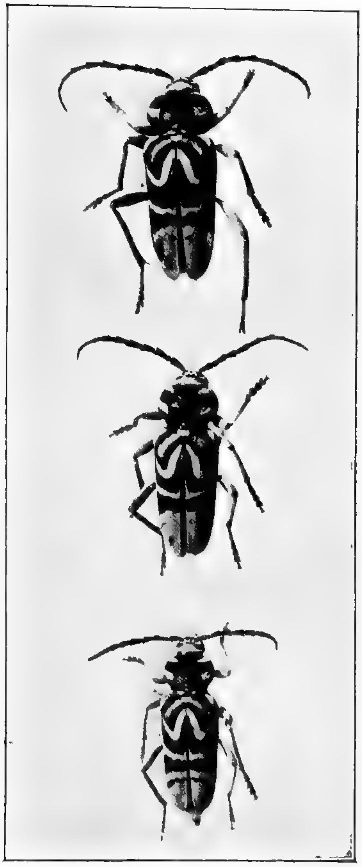


Fig. 1 Maple tree borer

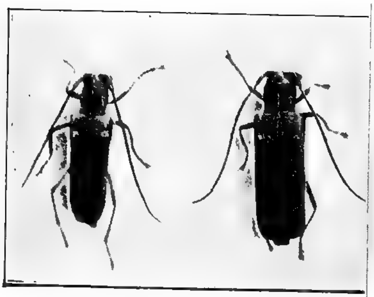


Fig. 2 Elm tree borer

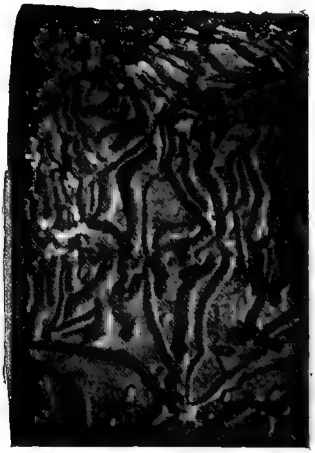
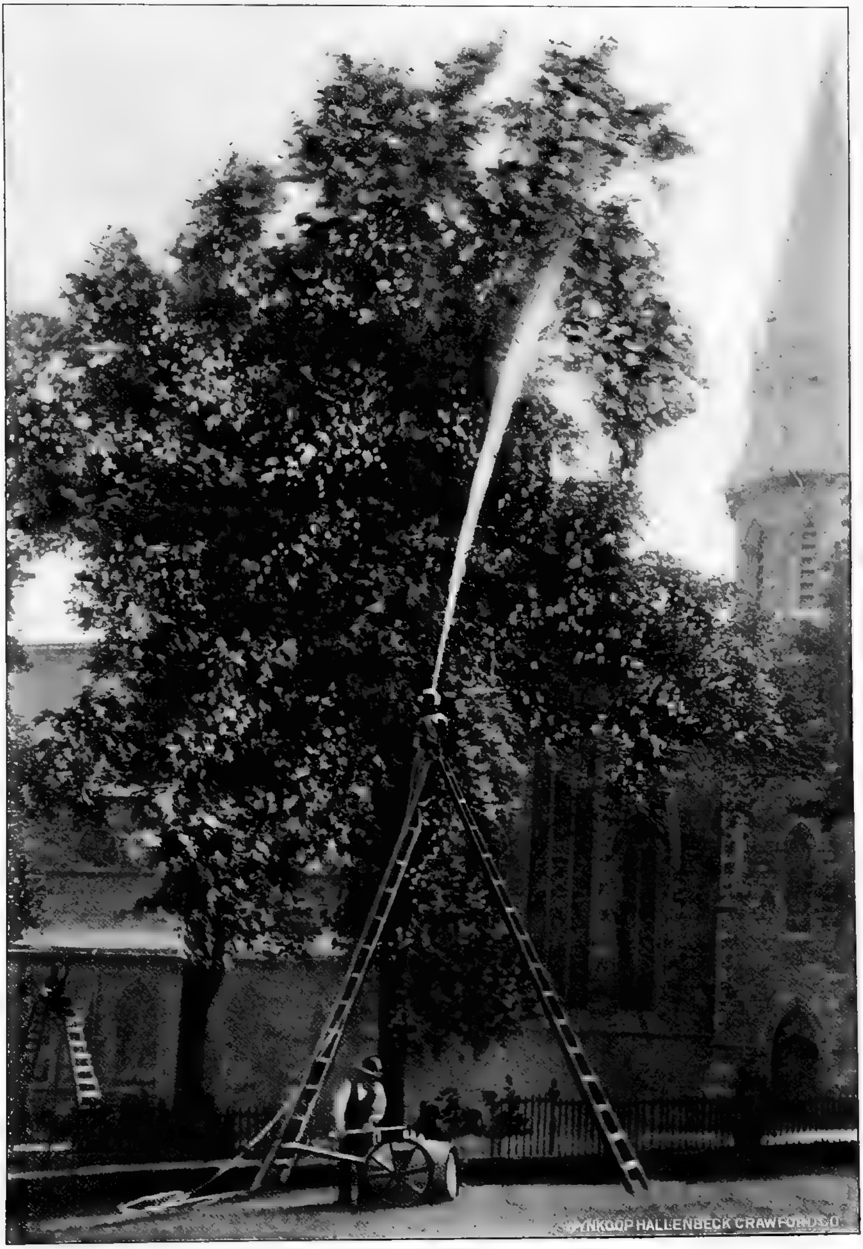


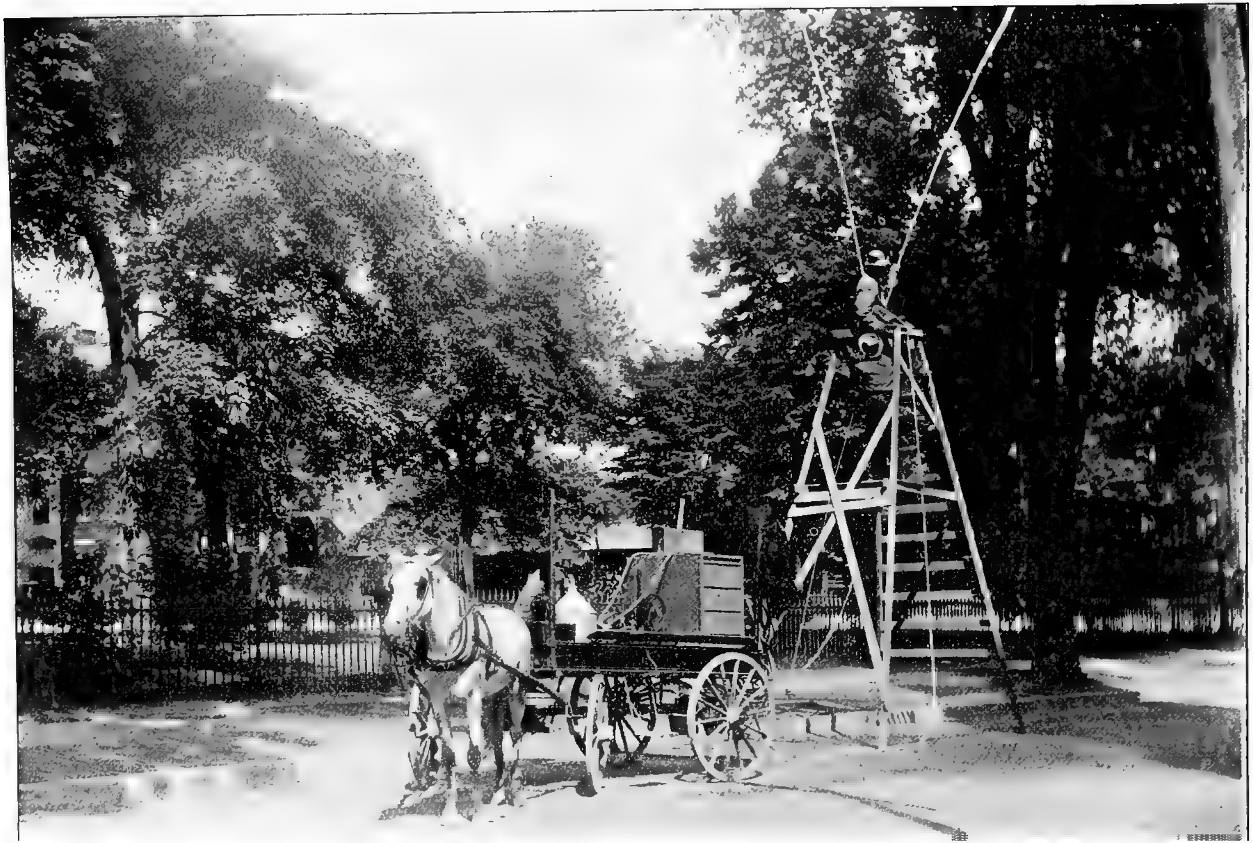
Fig. 3 Work of borers

Plate 4



Hand spraying outfit in operation

Plate 5



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INSECTS INJURIOUS TO SHADE TREES AND ORNAMENTAL PLANTS

NEW JERSEY

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181

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NEW JERSEY
AGRICULTURAL EXPERIMENT STATIONS
BULLETIN 181

MARCH 2, 1905.

Insects Injurious to Shade Trees and Ornamental Plants.

BY

JOHN B. SMITH, ENTOMOLOGIST.

Bulletin No. 103, dealing with "some insects injurious to shade trees," was published in October, 1894. The demand for it was so great that the edition was soon exhausted, and since that time there has been increasing demand for another publication covering the same ground.

During the last decade general interest in trees and ornamental plants has increased greatly. There are more village and town improvement societies and more landscape gardeners, nurserymen and florists. Several of our cities and towns have park commissioners, shade tree commissions or some official whose duty it is to look after the trees in the streets, parks or other open places in the municipalities. More attention is now paid by individuals to their surroundings and, particularly where dwellings are set in open grounds, large or small, intelligent effort is made to produce pleasing results. Shrubberies and hedges have been and are being set out in greater number and variety than ever before, and, as a rule, the plantations are kept in good condition.

City trees labor under disadvantages which are not always realized by those who have them in charge. It is quite usual for the root system to be largely cut off from connection with the surface; pavements may come within a foot or two of the trunk, leaving only a small breathing space, and, as for the rest, the tree is expected to get what nourishment and moisture it needs from the soil beneath the covering of stone or concrete. It is not generally understood that a tree makes continuous demands upon the soil and that each year some of the plant-food originally in it is exhausted. As a tree increases in size, it therefore finds increasing difficulty in securing an amount sufficient to keep it in health and vigor.

It happens frequently, also, that when digging trenches for water, gas or other pipe lines, roots are cut and much of a tree's feeding surface is absolutely destroyed. Furthermore, leaky gas pipes poison the soil; sometimes only a little, sometimes to an extent sufficient to kill all neighboring roots or even entire trees.

In other cases, trees on even well-kept grounds are starved; but in a different way. Instead of stone or cement there is a soil covering of sod, kept in the best possible condition, frequently cut and rolled, while the leaves that fall in the autumn are carefully removed and burned. Where fertilizer is put upon the ground at all, there is usually only enough for the sod, and the feeding grass roots are present in such abundance that very little gets below them to the tree roots. Moisture is absorbed in the same way, and frequently a tree suffers from drought even if rain has fallen sufficient to keep the grass in good condition. It is true that the feeding roots of trees extend down deeply and that they obtain food and moisture far below points accessible to grass roots, but in the course of years, if nothing is added, the tree exhausts all available food and begins to suffer. This is particularly true of those forest trees that have been left when the original woodland was cut, and many an oak, hickory and chestnut is dying from starvation whose owner would pay heavily to save it, did he only know how.

From the entomological standpoint these matters are important, because many insects do not attack trees until they show signs of weakness, and that is especially true of borers. When a tree becomes thoroughly infested by borers, there is little hope of saving it; the thing is to prevent attack by keeping the trees in healthy, growing condition. This applies generally, and one of the best methods of preventing insect injury is to keep trees and shrubs in as thrifty a condition as possible. See that there is abundant plant-food and water available, and treat the trees as you would other living beings. Plants have life—different in kind, perhaps, from that of animals—but nevertheless a life that needs nourishment and favorable conditions. Plants suffer from insect attack in almost all their parts, but we have, generally, to deal only with those that injure either the foliage or the growing shoots, and these may be forms that devour the foliage directly or suck the juices from the tissues. There is no one insecticide that kills all kinds of insects under all conditions, and it therefore becomes necessary to consider the leading injurious species in a somewhat systematic way, indicating under each heading just what materials should be used.

PLANT LICE.

Plant lice are small, usually green or brownish insects found on the under sides of leaves or on growing shoots, that multiply rapidly and nourish by sucking the plant juices. The mouth-parts consist of a jointed beak covering three or four very slender lancets, by means of which the tissue is punctured. An individual plant louse is rarely more, and generally less, than one-eighth of an inch in length, slender and capable of taking only a small amount of sap from the plant. When the lice are few their injuries are unnoticed, but frequently they are so abundant that the drain becomes serious. Every leaf may be burdened by dozens, or even hundreds, and the insects are not satisfied with taking just enough to maintain life; they pump continuously, and, when full to repletion, eject the excess through either the anal opening or through two little honey tubes near the end of the body. Where plant lice are numerous this honey dew, as the excreted juice is called, is sometimes so abundant as to coat the pavements with a sticky mass. The leaves themselves become covered and it forms an excellent surface for a black soot-fungus, that tends to choke the leaves, and so kill them. We have, therefore, not only the direct drain upon the foliage, but also a secondary effect due to clogging. Norway maples, among the shade trees, are the greatest sufferers; the tulip and elms also are more or less troubled, while

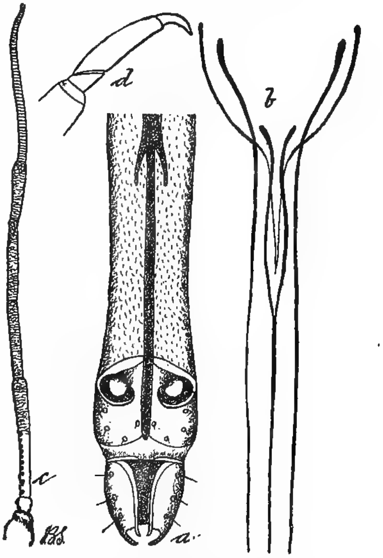

Fig. 1.
Mouth structures of a plant louse: *a*, the beak; *b*, the piercing lancets; *c*, antenna or feeler; *d*, the foot.

linden and the others that are usually planted are practically exempt. There are plant lice on all, but on only those mentioned is there any habitual increase to an extent that makes them a nuisance. In the garden, on most shrubbery and on ornamental plants generally, plant lice often become annoying, and even destructive. *Cratægus* is especially liable to attack, and the tips will curl, twist, turn black and become very unsightly, if nothing is done to check the insects. The apple, among the tree fruits usually planted in gardens, is the only one that suffers to any considerable extent. Of the small fruits currants are most likely to be troubled, and among the flowering plants roses suffer most. There is hardly a plant or shrub that may not at some time become badly infested by plant lice, and the methods of dealing with them should be known to all.

Remedies for Plant Lice.

Plant lice eat no part of the plant itself, and it is absolutely impossible, for that reason, to reach them with any of the stomach poisons. Paris green, arsenate of lead and all other materials that kill by being eaten are of absolutely no use against these little sucking pests. They can be reached only by contact poisons, which act through the spiracles or breathing pores at the sides of the body.

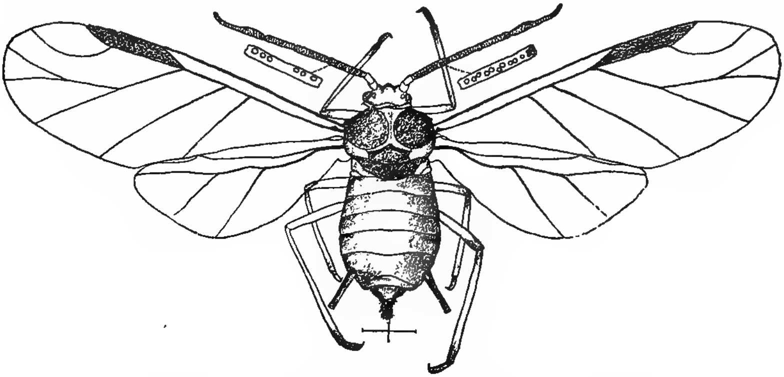

Fig. 3.
Apple plant louse, winged form, showing the honey tubes near end of body.

There are two kinds of contact poisons: those that act mechanically by clogging the pores and those that penetrate into the body and poison directly. Soaps are clogging in character, and so are oils in

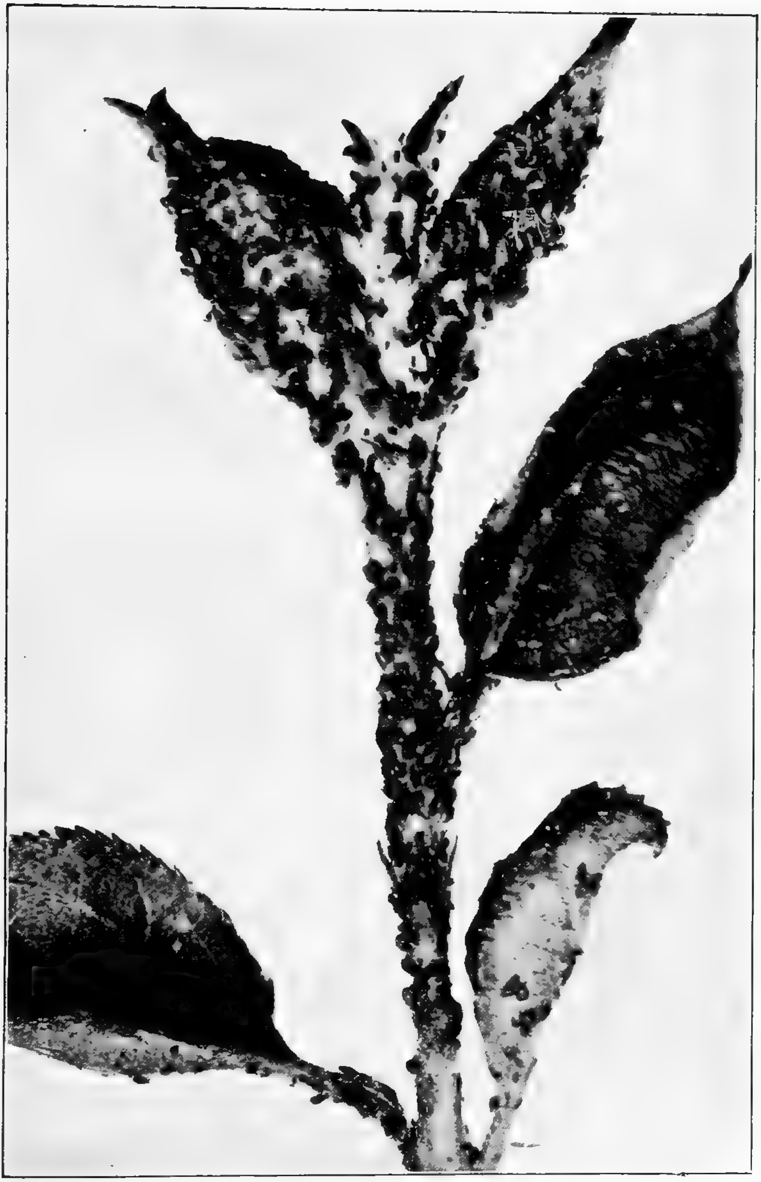

Fig. 2.

An apple twig infested by plant lice: shows how the insects congregate in great numbers.

general; but the petroleum oils are internal insecticides as well. Tobacco decoctions and all dry powders act only when they enter the spiracles and get into the body of the insect. Dry powders are effective in proportion to their fineness; coarsely ground tobacco, for instance, will be absolutely useless, where a sample that is finely ground may be effective. In the one case the particles cannot penetrate through the spiracles and hence do not affect the insects at all; in the other they get where they can exercise their specific effect and the insects suffer accordingly. In any case thoroughness in application is absolutely demanded.

Experience has shown that sprays are better than dry powders, as against plant lice, and that the finer and more forcible the spray the better its effect. The cleanest, and on the whole a very satisfactory application on flowering plants, is a tobacco decoction. There are now upon the market several tobacco extracts, which may be diluted with water and applied without further preparation. All these extracts, so far as I have used them, are more or less satisfactory; but in every case it is necessary to use them about twice as strong as is recommended on the label. Furthermore, it will be found that not all kinds of aphides respond equally well. Green lice, in general, succumb more readily than brown or black lice, and some of the very smooth black forms resist so strongly that it is almost impossible to kill them with tobacco alone. Instead of the extract, a tobacco soap may be used, and that is more effective, because it combines a clogging with the direct poisoning action.

Among the soaps the whale or fish oil preparations are much the most effective. They usually come in paste form, although some are dried out so as to cut into cakes; but in either case about one pound of the soap in from four to six gallons of water will be satisfactory. The tobacco preparations are usually harmless to plants at all strengths. The soap mixtures are caustic and tend to burn or otherwise injure foliage, so they must be more carefully used. One pound to four gallons of water is usually harmless to all but the tenderest of plants; but where there is any doubt, one pound to six gallons should be first tried, and if this is not effective within a day or two, another application should be made, increasing the strength until the insects are killed or the plant shows signs of becoming injured.

In the garden plant lice are rather easily kept in check by the use of tobacco or soap mixtures; but in all cases the applications should be made before they become abundant enough to do injury. Unless the insects are actually touched by the mixtures, they will not be harmed; it is therefore important that they should not be allowed to become numerous enough to curl the leaves, to form a protection for the specimens beneath them. Two or three applications of moderate strength at short intervals are better than a single application of a strength that is dangerous to foliage.

If whale oil soap is not available, laundry soaps may be used and particularly those that contain a percentage of naphtha or kerosene. There are several soaps of that kind on the market, and they are almost as effective as the fish oil combinations. Greater care must be taken with ordinary laundry soaps than with either of the others.

Potted plants, if they are treated with soaps, should have the surface of the ground protected that the suds may not get into it. If the soap is emulsified with soda, as it usually is, this will poison the roots of the plants if it gets to them. Outdoors no reasonable application is likely to influence the soil.

Shade trees, when of any considerable size, cannot often be satisfactorily treated for plant lice, because it is almost impossible to reach all the insects; but if they are of moderate size and the infestation is bad, fish oil soap offers the best chance for good results.

Natural Enemies.

Plant lice have many natural enemies and their increase depends largely upon weather conditions, but there is no one condition which is uniformly favorable or unfavorable to all. Some thrive during hot, dry weather; others do better in a season that is cold and moist. The latter conditions favor the development of that species which is so abundant upon the Norway maples early in the season, and usually after a cold, wet spring a change that results in a few days of hot, dry weather will mark the end of the attack upon that foliage.

It will be always noted that whenever plant lice increase abnormally their predatory and parasitic enemies also increase, and that somewhere about the middle of the season the tendency is to re-establish a balance, the plant lice decreasing to normal numbers. This does not apply in all cases, but may be considered a rule, yet there can be no dependence upon these insect enemies; whenever an injurious species increases to such an extent as to threaten harm, destroy it, if at all possible.

LEAF HOPPERS.

Leaf hoppers are small, oblong insects, tapering backwardly, usually green or yellowish in color; sometimes prettily marked, with a slender body and blunt, rounded head. They rarely exceed one-eighth of an inch in length, are usually found on the under sides of leaves, and, when adult, hop and fly readily. Shade trees are not usually much attacked by them, but garden plants are frequently infested. Roses and currants are especially liable to attack, and when the hoppers are at all abundant the leaves become first yellow-dotted and afterward brown and dry. Grape-vines are also very liable to infestation by these insects, which cause the early browning and drying up of the leaves long before the fruit is ripe. Quite a number of other garden plants are infested, and of the fruit trees, the apple is again the one most liable to attack. In general, all leaf hoppers have much the same habits. They appear early in the season as small, greenish, wingless creatures, running about on the under sides of the leaves and jumping only when seriously disturbed. About midsummer they become winged, and then, at the least touch or disturbance, they jump and fly. They continue throughout the summer and most of them winter in the adult stage.

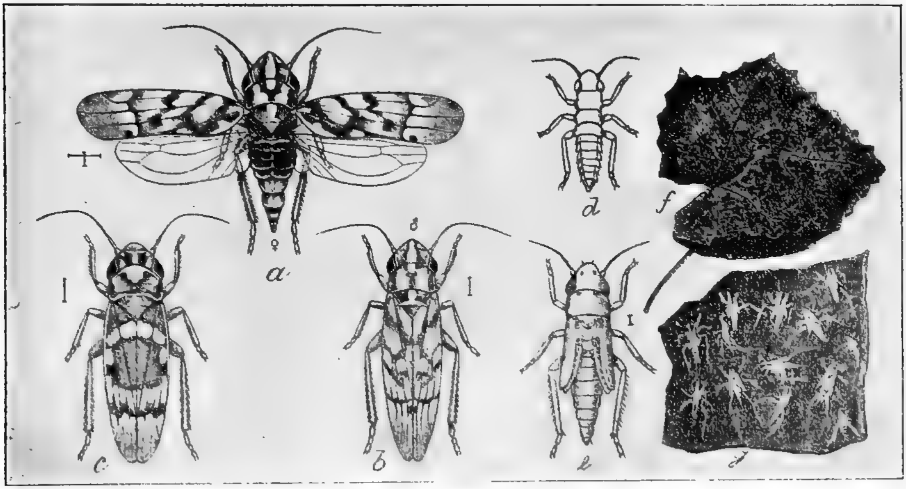

Fig. 4.

The grape-leaf hopper: *a*, adult with expanded wings; *b*, *c*, same with wings folded as at rest, variations; *d*, larva or nymph; *e*, pupa; *f*, an injured leaf; the cast skins on the under side of the leaves. From Marlatt, U. S. Dept. Agl.

Remedial Measures.

To control these insects, persistent work is required. Where they have reached the flying stage it is necessary to fill the air around the treated plant with the spray mist, so that the insects, even if they leave the plants and fly, will encounter the insecticide and be killed by it. As they feed like plant lice, they are equally immune against arsenical preparations, and must be reached by contact poisons. Tobacco is not nearly so satisfactory as the soap mixtures, and of the soaps those carrying kerosene or naphtha are best. Instead of soap mixtures, the kerosene emulsion or one of the soluble preparations of kerosene or crude oil may be employed, and all these are effective in proportion to the thoroughness with which the application is made. Here, also, the element of time is of importance. If the applications are made before the insects are winged, they will be easily hit upon the plant and most of those touched will be killed. If the application is made afterward, many will get away; or, even if they are hit by the spray when upon the plant, it does not reach the spiracles, which are protected by the wing covers. It is really better, therefore, to disturb the insects so as to cause them to fly, the spray being directed in such a way as to hit them in the air. As to the strength of the mixtures, that may be as recommended for plant lice.

SCALE INSECTS.

Scale insects are among the worst pests of the garden, and some are seriously troublesome on shade trees as well. Among the latter, the soft maples are especial sufferers from the cottony maple scale; the hard maples suffer to a less extent from a *Pseudococcus,* and the tulip tree is attacked by a soft scale. Nut trees are often infested by the oyster-shell bark louse, which is also quite common on poplar and willow, while only occasionally troublesome on elm and maple. In the garden, scale insects are even more plentiful, almost all shrubs and most of the ornamental plants suffering to some extent. The San José or pernicious scale attacks almost everything except privet and cherry; the oyster-shell bark louse sometimes ruins lilacs, is common on *Cratægus, Euonymous* and many other shrubs, as well as on apple. The scurfy scale is usually less abundant, but is sometimes common enough on apple and pear. The rose scale attacks blackberry and raspberry, and on roses sometimes causes considerable trouble.

Scale insects are those which secrete and cover themselves with a waxy or horny shield or scale that protects or hides them from view. Soft scales are so called because the surface covering is yielding in texture and forms part of the real insect: there is no separation between scale and insect, and any injury to the scale is an injury to the insect itself. Armored scales have the shield-like covering separated from the creature that produces it; the latter lies free beneath its shelter and it is quite possible to lift the scale from its attachment without disturbing the insect. It results from this that armored scale insects are difficult to reach with insecticides, because they are protected from all but the most corrosive and penetrating materials. Scales differ in thickness and some are much more easily pierced than others. There is also a great difference in their life history, and no one method will answer for the destruction of all. They agree in having a minute, six-footed active larva, which crawls about for a few hours—sometimes a day or two—and then inserts the long, slender lancets that serve it for mouth-parts into the plant tissue. Within

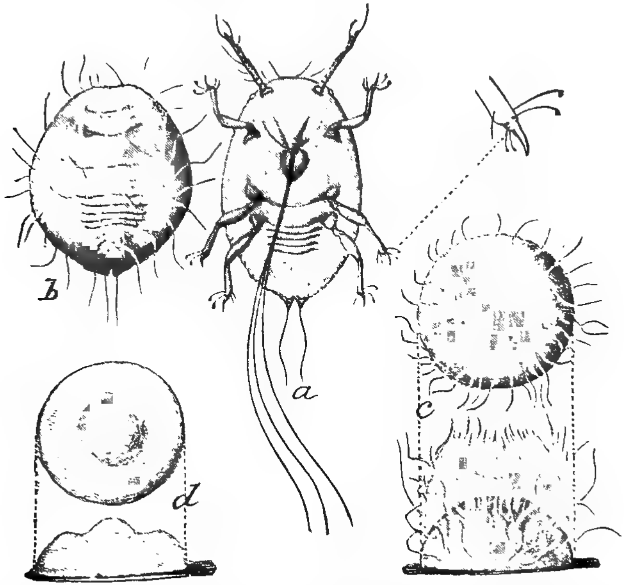

Fig. 5.

The formation of a scale: *a*, the larva with its mouth filaments extended; *b*, the larva has set, begun to feed, is becoming more rounded and waxy filaments are exuding from the surface; *c*, the insect has become circular and the waxy filaments cover it completely; *d*, the filaments have run together and form the first scale. From Howard, U. S. Dept. Agl.

a few hours after it begins feeding waxy filaments are produced over the surface of the body, and these, when sufficiently dense, coalesce and form the first covering or scale. Beyond that point the histories differ and each species must be taken up by itself.

THE COTTONY MAPLE SCALE.

Pulvinaria innumerabilis, Rathv.

Besides occurring on maple, this insect is also found on Osage orange, grape and Virginia creeper; on the latter, most often, after the maple. In some years and in some cities the soft maples are so seriously infested that they become wilted and sickly, while the stone flagging on the street beneath is coated by a black, sticky substance. This is the honey dew excreted by the insects, and on which a black fungus flourishes luxuriantly. The injury is therefore similar to that caused by plant lice, and both drains the trees directly and injures them indirectly by choking the foliage.

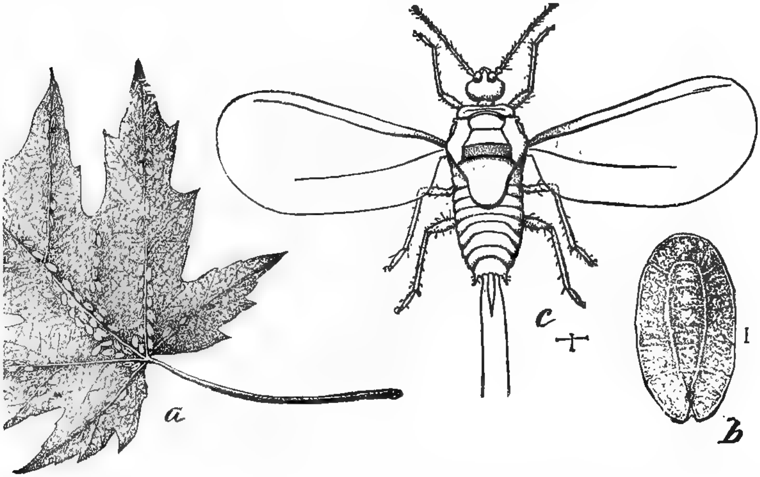

Fig. 6.

The cottony maple scale: *a*, young set along the ribs of a leaf; *b*, one of the recent sets, enlarged *c*, male, much enlarged. From Div. Ent., U. S. Dept. Agl.

The species usually attract attention late in May or early in June, when the gravid female excretes from beneath the scale a mass of white, waxy or cottony material, among which the eggs are laid.

She is then more than a quarter of an inch in length and appears as a white fluffy mass, with an oval brown head, which is really the scale itself, although forming less than half the length of the apparent creature. This female feeds ravenously, pumping sap in such quantity that there is a constant dripping to the leaves and ground below. An enormous number of eggs is produced—between 1,000 and 2,000—and these are all lodged in the cottony mass. They are brown in color, exceedingly minute, and, when all are laid, actually force the mother scale from the surface of the twig until it is attached only by its mouth filaments and by the adhesive character of the white mass. The eggs begin to hatch about the middle of June and continue until well along in July, producing a larva of the usual form and brown in color. The great bulk of the hatching comes about the beginning of July, and at that time infested twigs literally swarm with thousands upon thousands of moving atoms. In a day or two they fix themselves along the veins of a leaf or on young twigs and begin to feed. The formation of the scale begins immediately, and about three weeks thereafter we have the first molt or change of skin. The waxy secretion or scale then increases in thickness and

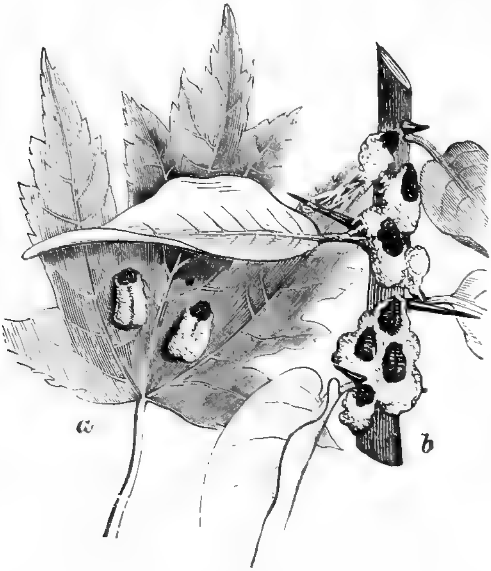

Fig. 7.

The cottony maple scales: *a*, females of *acericola* on a leaf; *b*, females of *innumerabilis* on a twig
From Div. Ent., U. S. Dept. Agl.

the difference between the sexes becomes apparent. Meanwhile, after all the eggs have been deposited, the adult female dies, and at almost any time afterward a heavy storm may wash off the white masses. On the other hand, when trees have been badly infested, remnants of the tufts remain in sheltered positions for months and make it seem as if the tree was still infested. As a matter of fact, the work of the hibernating forms is done by the middle of June; after that, whatever injury occurs, is caused by the setting young.

When the first molt has been reached the males, remaining slender, soon attain full size and cover themselves with a thick coating of whitish waxy material. The pupa forms within the larval skin, the parts of the future adult become gradually distinct, and a pair of long, waxy filaments is produced from near the end of the body; the protrusion of these filaments indicating the approaching appearance of the male. The posterior end of the scale is in this manner raised up and the perfect insect backs out, with wings held close to the side of its body. During this period the females have grown larger and broader across the posterior region; but the scales have remained flat, or with only a slight median ridge. Just before the males appear, there is another molt and the color changes to a somewhat deeper yellow with deep red markings. The males mature during August and early September, seek the females and then die. The females gradually lose their bright red markings, change to a deep brown color, become more convex, secrete a thicker coating of wax and the scales become more distinctly ridged. They do not lose the power of motion as do the armored scales, and, before the leaves fall, migrate to the twigs and fix themselves—generally on the upper side. They feed as long as the sap flows, then become torpid and remain in that condition until the following spring, when feeding begins again and with it the development of the eggs.

Remedial Measures.

When this insects attacks shrubs, vines or the lower parts of trees that are easily accessible, the infested twigs and branches may be trimmed off and destroyed as soon as the cottony masses are noticed. As they usually set close to the tips, this is often possible without mutilating either tree or shrub. Even shade trees of considerable size can be so dealt with when the infestation is not unusually bad.

The cuttings should be burnt or taken to some distance from any plants likely to become infested by crawling young, should any hatch. If this cutting is for any reason undesirable, the question of applying insecticides arises.

In ordinary seasons the insects are not sufficiently abundant to be a real menace to a tree and may be left without treatment. There is sometimes a period during which they become increasingly abundant; but with this increase comes also a corresponding development of the natural enemies. So, as a rule, a season, during which the insect is unusually plentiful, is followed by one in which it is practically harmless.

Where it is desired to keep trees or shrubs entirely clean, a diluted petroleum, either crude or distilled, to which some soap has been added, will be most useful. This matter of insecticides is more fully referred to later, and in this connection it is only necessary to say that, whatever is used, it should be applied as soon as possible after the fluffy masses become fully apparent on the trees. The oily or soapy materials penetrate into the masses, clog or mat the cottony fibres and make it impossible for the developing young to get through.

If, for any reason, it is impossible to make an application at that time, it will be better to wait until the young are noticed. That can be easily determined by cutting an infested twig and placing it in a box with white paper. As soon as the paper begins to be covered with brown moving atoms, the time is at hand for an effective application, and then a thorough spraying of the infested trees with fish oil soap, one pound in five gallons of water, will result in the destruction of the young. At that period the insects are entirely unprotected, and even under normal conditions not more than 2 or 3 per cent. of the larvæ ever succeed in fixing themselves to the surface of the plant tissue. A thorough drenching with a proper insecticide will reduce this percentage to so small a one that the trees may be considered clean for the season following.

As the tendency of this scale is always toward the outside, it will not be necessary to get into the interior of the tree, nor to spray beyond the region actually infested by the white scales. It is quite usual for trees to have the upper branches clean, even though the lower ones are badly infested. In such cases the lower branches only need be treated, care being taken to reach the full extent of the infestation and a little beyond it.

THE TULIP SOFT SCALE.

Lecanium tulipiferæ, Cook.

The tulip, *Liriodendron tulipiferæ,* is deservedly a popular shade tree in many localities, and is, as a whole, fairly free from insect injury. Plant lice attack it in some localities and this soft scale has increased to such an extent as to seriously threaten the smaller trees. The scale, as it appears in midsummer and later, is almost hemispherical, nearly a quarter of an inch in diameter,·gray in color, slimy to the touch and repulsive to the eye. It crushes easily when handled and the body contents have a deep purplish color, with an odor that is distinctly offensive. It is the largest of its tribe in New Jersey and so disagreeable that many persons have preferred to cut down their trees rather than attempt to deal with the insect.

The female scales grow until late August, and in early September are mature and ready to reproduce; young then appear beneath the body in great numbers. They are minute, black, somewhat flattened above, oval in shape and have the body segments clearly marked. Thousands of these larvæ swarm in early September on and near the infested branches, setting so close together that they conceal the bark completely and give it their own dull, black tint.

They begin feeding at once and make some growth before cold weather sets in, being at that time almost one-sixteenth of an inch in length, jet black and quite visible to the naked eye. The adults dry up and many of them drop or are washed off during the winter, so that most are gone when spring again comes around. At that time the larvæ resume growth, and become large enough to attract attention in June. Late in July the insects are sexually mature and the life cycle is complete.

This species is kept in check by a small caterpillar that feeds upon the young. In September, when the female scales are reproducing, we often find, under the scale, a little reddish caterpillar which lives in a web and feeds greedily on the larvæ. Sometimes every scale on a twig shelters one of these caterpillars, which make galleries from one point to another, occasionally forming masses of silk that hold together all the scales on one twig. Unfortunately, these caterpillars cannot eat the larvæ as fast as they are produced, and a considerable number always escape to set upon the growing twigs.

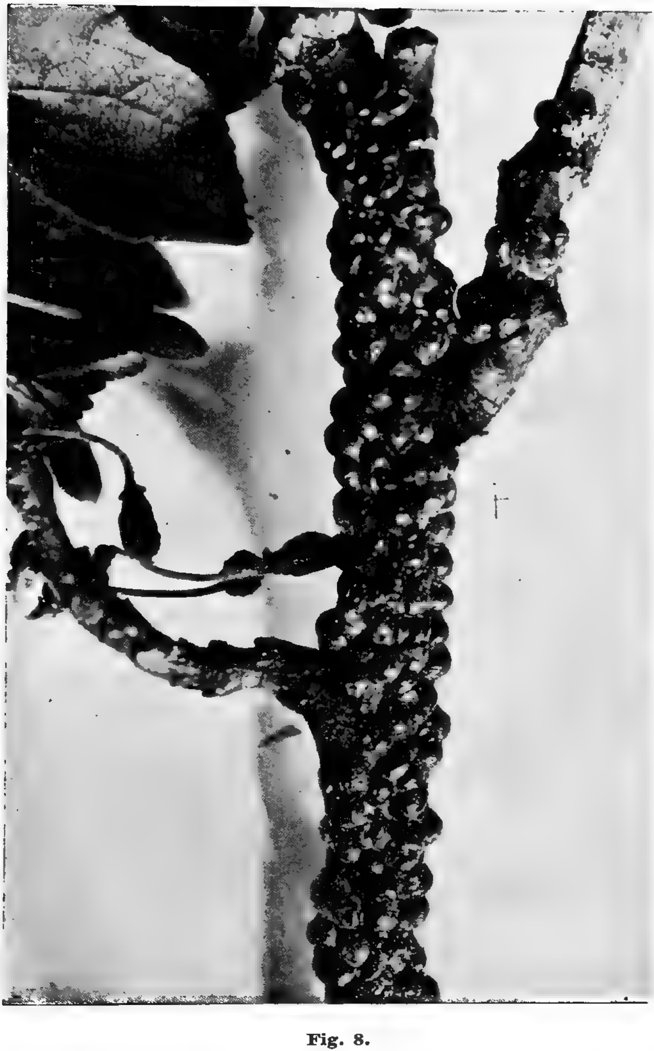

Fig. 8.

A soft scale as it appears on badly-infested twigs.

Remedial Measures.

This is another of the species that may be reached most satisfactorily in winter. Undiluted crude oil may then be used under the restrictions hereinafter mentioned, and will kill all the insects that it touches. As the scale grows only a little during the fall, it is easily penetrated by the oil and good results are generally obtained from the application. As this tree sometimes grows to a great size, and as the scales may occur on all parts of it, the application of insecticides is a considerable task; nevertheless, with a proper outfit, it can be accomplished. Theoretically, the best time to make applications is in September, when the young are just setting; they are then less resistant, and even fish oil soap—one pound in four gallons of water—will answer. On the other hand, the foliage then interferes and makes it more difficult to reach the points at which the young are setting.

THE OYSTER-SHELL BARK LOUSE.

Mytilaspis pomorum, Bouché.

This insect derives its common name from its shape, which is like that of a long, narrow oyster, and so characteristic as to be easily recognizable. The cast skins are at the narrow end of the scale and form what is apparently its head. The females come to maturity late in August, and egg-laying continues until well along in September, when the space below the scale will be found entirely filled with from forty to one hundred and ten minute, whitish eggs, the usual number being somewhat less than one hundred. These eggs remain through the winter protected by the scales, and the larvæ hatch during the early part of the following June. Growth is slow; there is only one brood, and when not excessively abundant the insect does not do much injury. It does, however, become excessively abundant at times, especially on lilac, apple and pear, which may become so covered that the shoots begin to die.

Walnut and butternut trees are very susceptible to attack and are sometimes killed, even when of considerable size. So willow and poplar are often infested to an extent sufficient to cause injury. Among fruit trees, apples are most susceptible; but it is rare for them to be so infested as to suffer harm.

Remedial Measures.

Where lilacs are badly covered it will be best to cut out all the scaly wood that can be spared. Lilac will stand severe trimming and does not require a long time to make new growth. If an infested hedge is carefully looked after and the bad shoots are kept trimmed out, this insect can be controlled without the application of any insecticides. Judicious trimming will also help willow and other infested trees and plants.

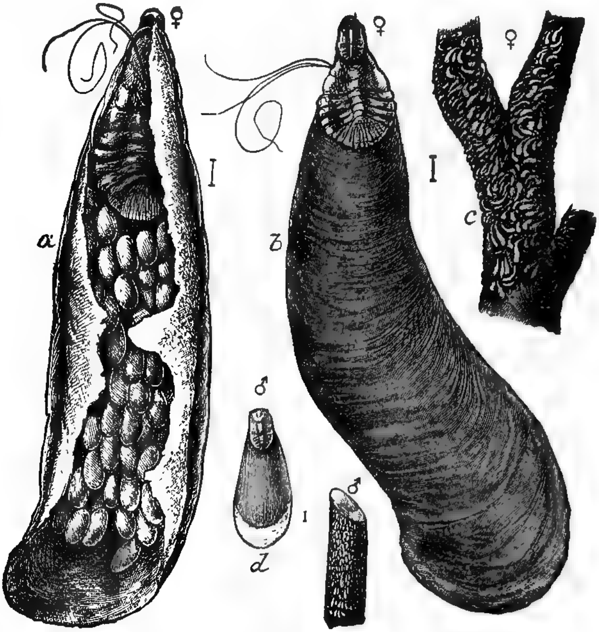

Fig. 9.

The oyster-shell bark louse, *Mytilaspis pomorum*, Bouche: *a*, female with the egg mass beneath the scale; *b*, same from above, showing the normal appearance of the species; *c*, a twig infested by females; *d*, the male scale, natural size and enlarged. From the Div. Ent., U. S. Dept. Agl.

If cutting out is not feasible, insecticides must be resorted to, and there is only one time when they can be applied with any prospect of success. It has been shown that the insects winter in the egg stage, covered by the female scales, and no application made during that season stands any chance of producing a satisfactory effect. Unless the scales can be actually washed off or corroded, nothing that covers them will affect the eggs underneath. It is in June, when the eggs hatch, that applications may be made to prevent the setting of the young. These applications may consist of fish oil soap mixtures, one pound to four gallons of water or of oil emulsions. It is impossible to say definitely just when spraying should be done; that will vary with the season and the year. It will be necessary to watch during the early part of June, to note the first appearance of moving larvæ, and as all the eggs hatch at about one time, a single application will generally be all that is needed. There is a period of about a week from the time of hatching, during which the scale covering is not dense enough to offer much resistance, when proper insecticides are most likely to be effective.

In a general way, this insect seems to be more troublesome in the northern parts of the State than in the south, although even in the south willows and poplars are sometimes very badly infested.

THE SCURFY SCALE.

Chionaspis furfurus, Fitch.

This scurfy scale, or "Harris Louse," is much broader than the preceding, very light gray in color and much thinner in texture. The cast larval skins are at the narrow end of the scale, and in general the life history is much like that of the preceding species. These larvæ also hatch during the early days of June, but are orange in color. The male scales are comparatively very small, narrow and almost white. The eggs are developed in September and are deep purplish-brown, varying from twenty to eighty in number, sixty being, perhaps, an average. Of the shade trees, poplar is most frequently infested, and in the garden currants among the small fruits suffer most. Among the fruits pear is most usually infested, apple coming next, and among the shrubs *Cratægus* is the usual host. There is only one brood in this State, and the winter is passed in the egg stage.

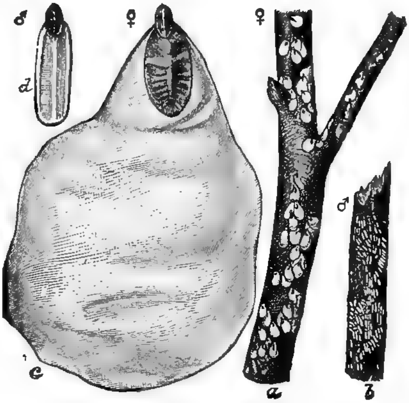

Fig. 10.
The scurfy scale: *a*, twig showing female scales; *b*, same, with male scales; *c*, female, and *d*, male scale enlarged. From Howard, U. S. Dept. Agl.

Remedial Measures.

In a general way, what has been said of the oyster-shell scale applies to this insect also; but as the scurfy scale is much thinner, winter applications may be also resorted to. Any of the caustic mixtures corrode the scales very readily, and whenever such applications are used as against the San José or pernicious scale, similar applications against the scurfy scale will be equally effective. It is usually not so much that the eggs are injured by the application, but the scales are destroyed and the eggs are washed out by rains and carried to the ground. Even a thorough coating of whitewash will in many cases destroy the insect, which is the most easily controlled of any that occur in injurious numbers.

THE ROSE SCALE.

Diaspis rosæ, Bouché.

This is a snow-white scale about one-tenth of an inch in diameter, somewhat irregular in outline; on the whole, broadly oval in contour. On a badly infested twig there will be seen, besides these broad scales, many of lesser size—not quite so white, more oval in form, and with the yellowish band or point projecting beyond the scale line. We also find a series of much narrower scales, ridged in the center, and these cover the male, all the broad scales being females in every instance. This species attacks rose, blackberry and raspberry, the rose being the most common host. It has a distinct preference for plants grown in the shade, and particularly where, besides being shady, the ground is also damp.

Hibernation may be in any stage from the egg to the gravid female, all stages being found during the winter months. By the beginning of March few eggs remain, the larvæ are generally covered and the majority of all the insects are females ready to reproduce. During May and June eggs and active larvæ are most commonly present, and there seems to be a continuous breeding throughout the season without a regular division into broods.

The larvæ are dull orange in color, with well defined black eye spots and well marked antennæ and legs. Unlike most other scale insects this larva, when it has once set, does not immediately cover itself with a waxy secretion. It may remain for several days entirely naked, and scale growth is both irregular and slow. If there are only a few of the insects and the plants are vigorous, no perceptible harm will be done; if the plants are well set with fruit or flowers and not too well fed, the scales sometimes cause considerable injury.

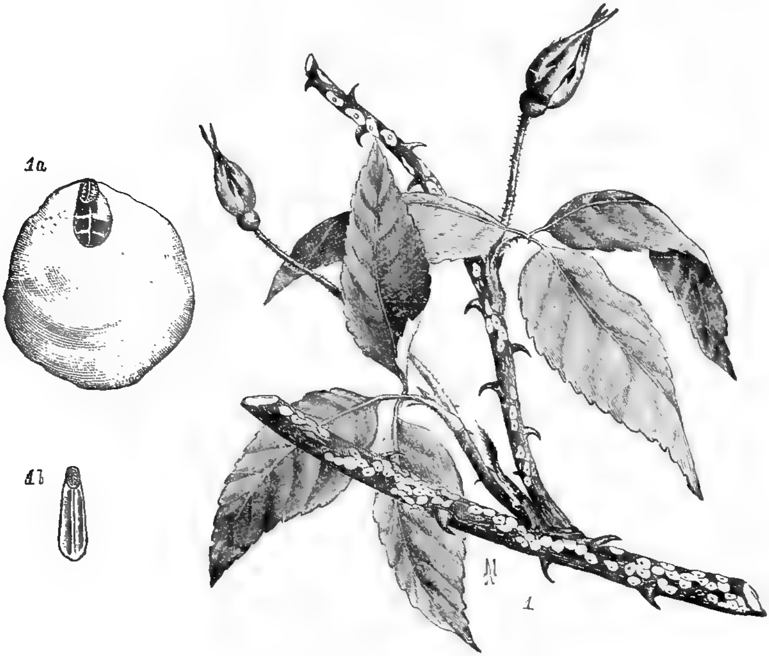

Fig. 11.
The rose scale: female enlarged at *a*; male at *b*. From Div. Ent., U. S. Dept. Agl.

Remedial Measures.

In the garden all that is usually necessary to control this insect is to admit light and air and to cut out the worst infested shoots. Rose plants can, as a rule, be entirely cleaned in this way, and blackberry and raspberry plants need little more. Judicious trimming in winter will be all that is necessary in most cases.

Sometimes rose plants are so situated that cutting back is not desirable and then a resort to insecticides is necessary. Winter applications are best and any of the winter washes recommended for the pernicious scale will answer. The covering is thicker than that of the scurfy scale; but is not so resistant as that of the other species here mentioned. As the insects pass the winter in all stages, one application may not be sufficient, and it will be better to make another toward the latter part of May, when those forms that were in the egg stage and most probably escaped will be in a condition to be reached by insecticides.

THE SAN JOSE OR PERNICIOUS SCALE.

Aspidiotus perniciosus, Comst.

This differs from our other common armored scales by its round form and small size. In size it is as a small pinhead; in shape not very different. In color it ranges from gray to black, the larger scales being usually gray, with a yellowish center. This yellowish center distinguishes the pernicious scale from some other forms that occur sparingly on shade and fruit trees. In its younger stages the scale is entirely black.

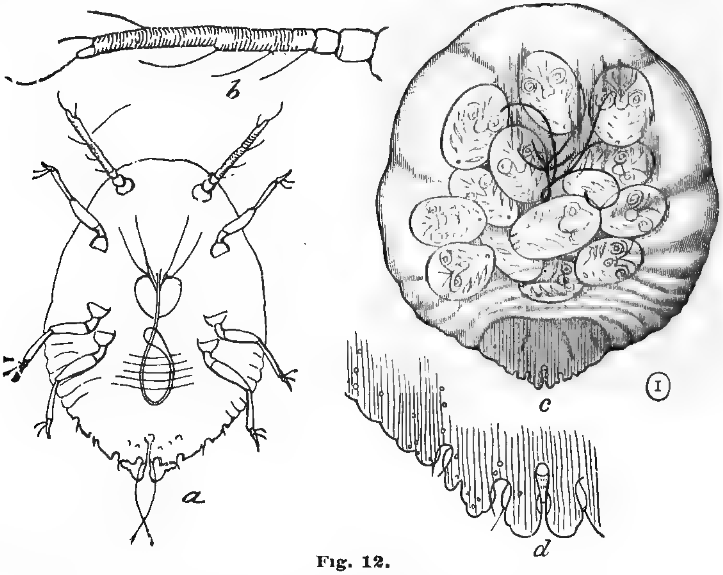

Fig. 12.

The San Jose scale: *a*, the new-born larva; *b*, its antenna; *c*, the adult female, taken from beneath the scale; *d*, the edge of the anal plate; all very much enlarged.
From Div. Ent., U. S. Dept. Agl.

This species infests almost every shrub and tree ordinarily grown in the garden, although it is not equally destructive on all. It does not attack evergreens, is rarely found on privet—never in numbers enough to be injurious—and seldom occurs on raspberry or blackberry so as to be troublesome. On all fruit trees, except cherry and quince, it is destructive; Osage orange, *Pyrus japonica,* purple beech and even *Citrus trifoliata* are seriously attacked and the Osage orange and *Pyrus japonica* are veritable nests in which the scale breeds and from which it may extend in every direction.

Shade trees, generally, are subject to attack; but except where they are young no material injury is caused. Young European elms may suffer severely, willows of all kinds are likely to be infested and cut leaf and Kilmarnocks are frequently killed. Maples may become infested and the silver maples sometimes considerably so; but I have yet to find a maple of any kind along the streets or in gardens that has been badly infested after it reached any considerable size. In fact, none of the ordinary shade trees have, in my experience, become sufficiently infested by this insect to make it of any account as a shade tree species. This is fortunate in view of the difficulty of dealing with it and limits the work that is to be done to fruit and ornamentals in the gardens.

The winter is passed in the half-grown condition, covered by a black scale. In spring growth is resumed and, somewhere during the early or middle part of May, males appear. They remain about for a day or two only, fertilize the females and disappear. The females grow slowly, and not until the 10th of June, in the latitude of New Brunswick, do we find larvæ. In South Jersey the insects begin breeding two or three days earlier and in the more northern parts of the State the 15th is nearer to the ordinary date when reproduction begins.

The larvæ are small, sulphur-yellow atoms, which are born alive, and each breeding female bears from six to eight daily for several weeks in succession. Usually, within twenty-four hours, the larvæ set, and almost immediately a whitish film forms over the surface. This is the first scale, and at almost any time after midsummer an infested tree will show moving larvæ, the almost snow-white recent sets and every stage from that point through a gray to a black scale. From the time the larvæ first sets to the time when it is sexually mature and ready to reproduce is a little less than five weeks, and the first born of a female may be ready to become mothers before the original female has ceased to reproduce.

Reproduction continues throughout the summer, and a single pair, starting in June, may become the ancestors of over one thousand million examples before the season closes. Reproduction is most active early in September, and throughout that month larvæ occur in abundance on infested trees. It is the season at which spread is most general and the agents of that spread are birds and other insects that visit the infested trees. The crawling larvæ get upon anything, including the backs of beetles and the feet of birds, and are carried for considerable distances, causing outbreaks where none had been looked for. An insect that attacks so many different kinds of plants, that breeds so abundantly, and that has no natural enemies to keep it in real check, is, of course, a pest of the first class; and so all gardeners have found it.

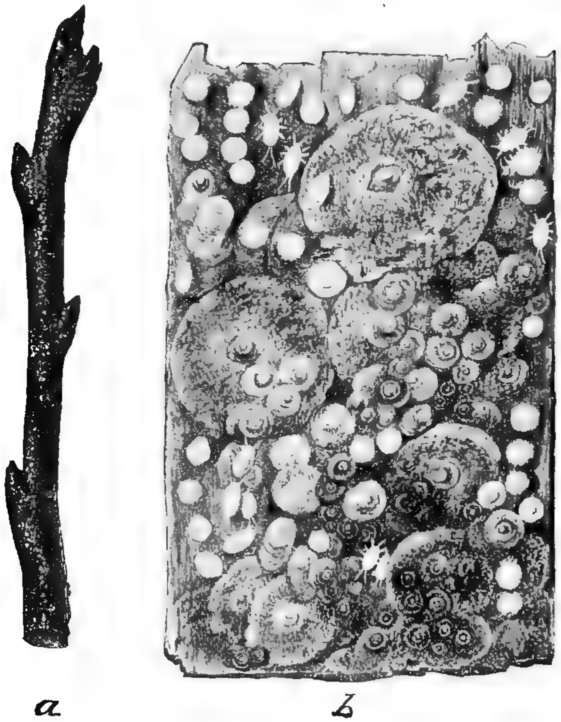

Fig. 13.
The San Jose scale: *a*, on a twig, natural size; *b*, as seen under a hand lens, much enlarged.
Div. Ent., U. S. Dept. Agl.

Remedial Measures.

Two sorts of campaign can be carried on against this insect. A summer series, directed at the larvæ, and a winter campaign, directed against the hibernating forms. None of the ordinary summer mixtures kill all stages of the scale without endangering the foliage. Larvæ may be killed by diluted oil emulsions or by soap mixtures; say for whale oil soap one pound in two or three gallons of water, depending upon the kind of plant; or the oils in a 5 or even a 10 per cent. dilution, according to the manner in which it is put on and the plant on which it is to be used. In any case, the application will kill only crawling larvæ and very recent sets. Applications must, therefore, be renewed at short intervals throughout the summer to obtain a really effective result. This sort of work is feasible in gardens that are under constant supervision, and in such places the insect can be almost completely cleaned out in a single season. The new forms of petroleum, made soluble in water, will be most effective aids in this sort of campaign.

For winter work more severe applications are necessary as against the scale, and possible with safety to the plant. Perhaps the safest to the plant and very effective against the insects, are the lime and sulphur washes, with or without salt, either boiled or combined by the heat of slaking lime; but these are difficult to make for a small establishment and belong rather to the orchard remedies.

Standing first in effectiveness, but somewhat dangerous in its application, is crude petroleum. Carefully used with an atomizer or through a fine nozzle, undiluted petroleum of a specific gravity of forty-three degrees or over, and made slightly warm, can be applied safely on plants of almost every description and will be almost certain death to every scale that is reached. There is a danger in the use of oil that must be recognized, but when that danger is kept in mind and the proper precautions are taken, there is no more satisfactory material.

An effort has been recently made to render petroleum soluble in water, so that it can be used with greater safety, and this has resulted in the production of a material called "Kill-O-Scale," by the Griffith & Turner Company, Baltimore, Maryland. This can be applied to plants of almost every description, at the rate of one part of the insecticide in twenty parts of water. It is almost too expensive for use in the orchard, but where a small area only is to be treated it is perhaps the best form in which the oil can be used. Diluted somewhat more, it is also valuable for summer work and more effective than whale oil soap.

Whale oil soap may also be used at the rate of two pounds in one gallon of water. At this strength the soap is itself likely to prove injurious, unless used late in the season.

THE MAPLE PSEUDOCOCCUS.

Pseudococcus aceris, Geoff.

This is a species which, while it belongs to the scale insects, differs from the others here dealt with in many points. About midsummer there may be found on the leaves and trunks of hard maples little, fluffy, white masses that somewhat resemble the cottony maple scale. At first the white shows in the crevices of the bark, then in all other depressions, and finally, in bad cases, the entire trunk may look as if thoroughly whitewashed. The insects will be piled, not in a single layer nor evenly distributed, but in masses half an inch thick or more; great clumps will occur in some situations and in others they will be sparsely scattered. On the leaves the masses will be found on the under side along the veins and whenever they are numerous the leaves may turn yellow and drop before the ordinary period.

If one of these fluffy patches be carefully examined it will be found to consist of a little mass of a stringy, wax-like material, beneath which and at one end is the body of the adult female and her eggs. This female is wingless, pale yellow and rather less than one-quarter of an inch in length. The eggs are also light yellow and are found numerously in the waxy secretions.

The larvæ that hatch from these eggs are like them in color and move about for a considerable period before selecting a place to fix and grow. After midsummer the winged males, which are reddish, will be found crawling over the waxy masses in search of the females. Reproduction continues throughout the season, and on some trees, when badly infested, the appearance is quite unique. No definite scale forms over this insect, which is protected by the waxy strings alone.

Remedial Measures.

As the trunks and branches of trees are selected by preference, we have in most cities and towns a simple and easy remedy. It consists of the ordinary garden hose with sufficient water pressure behind it to wash the insects from the tree trunk. In a number of localities this has been resorted to, and always with good success.

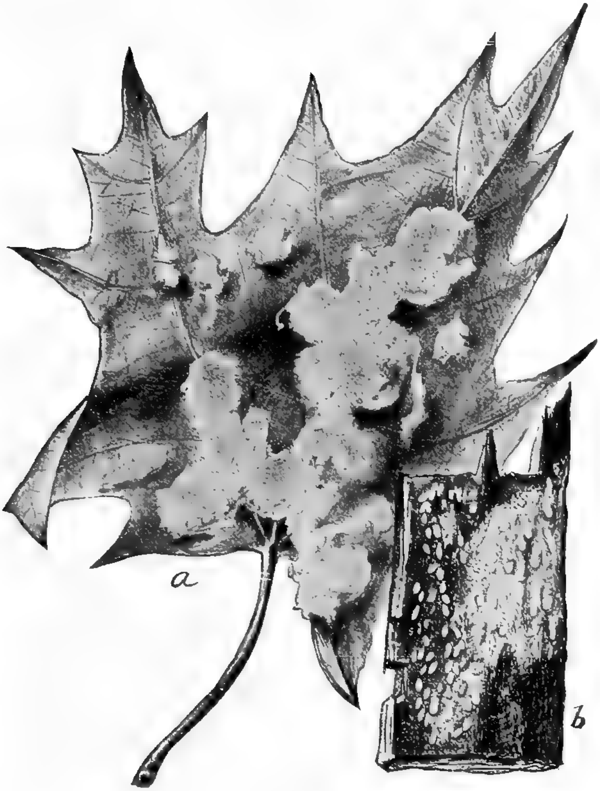

Fig. 14.
The maple pseudococcus: *a*, the cottony masses covering the adult females on leaf; *b*, young of both sexes on bark. From Howard, U. S. Dept. Agl.

The injury to the leaves has never, in my experience, been of sufficient account to make it worth while to use insecticides. They should be raked up as they fall and burnt, together with the insects that may be on them at the time.

Where water pressure is not available, the trunks of the trees may be sprayed with strong soap suds of any kind, or with any of the dilute oil mixtures.

BORERS.

Shade and fruit trees are equally subject to the attacks of borers that feed beneath the bark or in the wood tissue. Sometimes the trunks are attacked; sometimes the branches, and occasionally the roots. Sometimes, beneath the bark, there will be shallow, irregularly winding galleries, ending in a larger, shallow chamber. This gallery is made by a flat-headed borer, called so because the anterior segments are broader than the rest of the body and much flattened, so that it can live in the shallow channel that it has made. Insects of this character usually attack weakened trees only.

Sometimes, also beneath the bark, we find a series of narrow borings—a single up-and-down gallery; one, two or three inches in length and about one-sixteenth of an inch in diameter, and, branching from this center, a large number of laterals, sometimes extending at right angles to the center and sometimes branching in every direction, but always so that they do not cross each other and gradually separate as they extend from the common center. The main gallery in this case has been made by a bark beetle, which laid its eggs on each side close together, and the lateral galleries have been made by the larvæ which hatched from the eggs. These pests also, as a rule, attack trees which are in a more or less weakened condition. This is not universal, applied to bark beetles as a whole, but it is the rule as applied to those that work in the shade and fruit trees that are usually planted. When a tree becomes badly infested by these beetles it might as well be cut out at once. The fact that it was attacked at all is an indication of weakness, and as the attack continues the tree becomes even more weakened and further subject to infestation until it dies. Borers of this kind are very apt to attack hickory and other forest trees growing in lawns or under such conditions that they do not receive a full supply of moisture and plant-food. The most destructive species on city shade treees is the

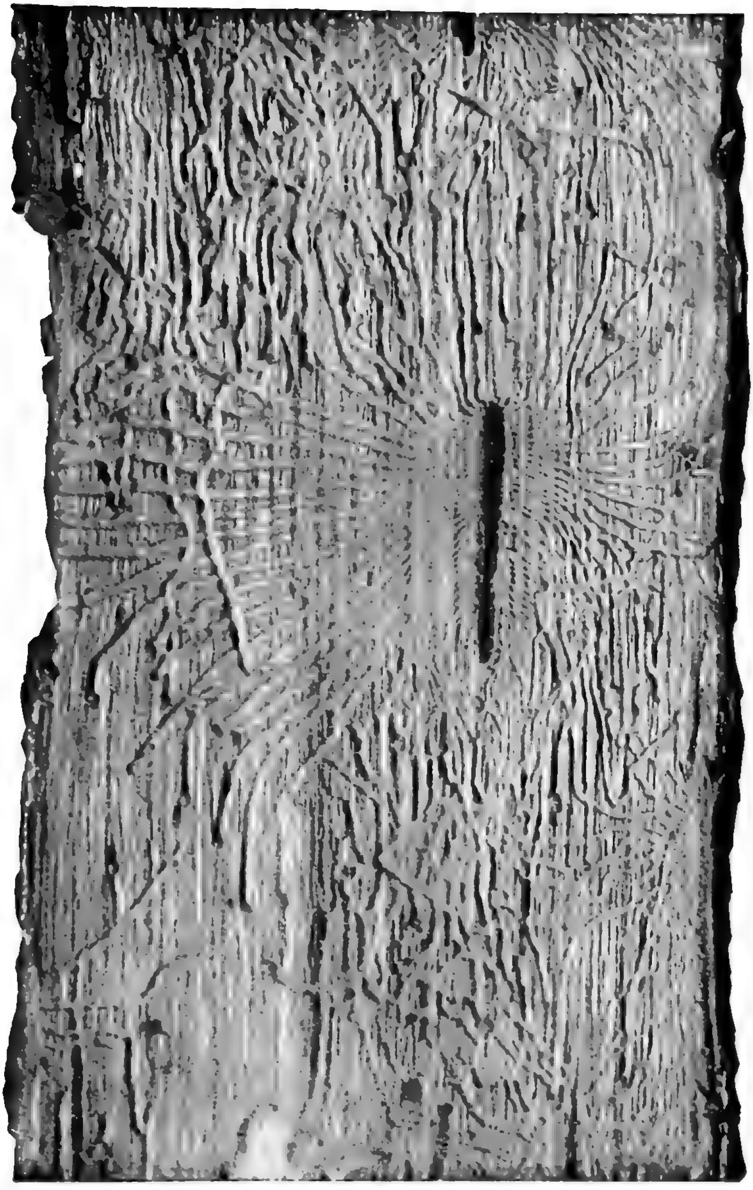

Fig. 15.

Work of a bark-beetle beneath hickory bark.

WOOD LEOPARD MOTH OR IMPORTED ELM BORER.

Zeuzera pyrina, L.

This is an insect that was accidentally imported over fifteen years ago from some European country and made its start at Hoboken. It spread from that point to Jersey City, and thence northward, toward Paterson, south to Newark, Elizabeth, and recently it reached New Brunswick. Practically all kinds of shade trees and many shrubs are attacked by the larva, which is both a borer and a true caterpillar. The parent moth is quite large, the males measuring an inch and a half and the females two and a half inches between the tips of the fore wings. These wings are white with numerous black spots, and the body is black spotted in its anterior portion. The head in the male has a pair of densely feathered antennæ or feelers, and the abdomen extends back an inch and a half or more. Altogether the creature is readily recognizable and is found, during the season in which it flies, around electric lights in the cities where

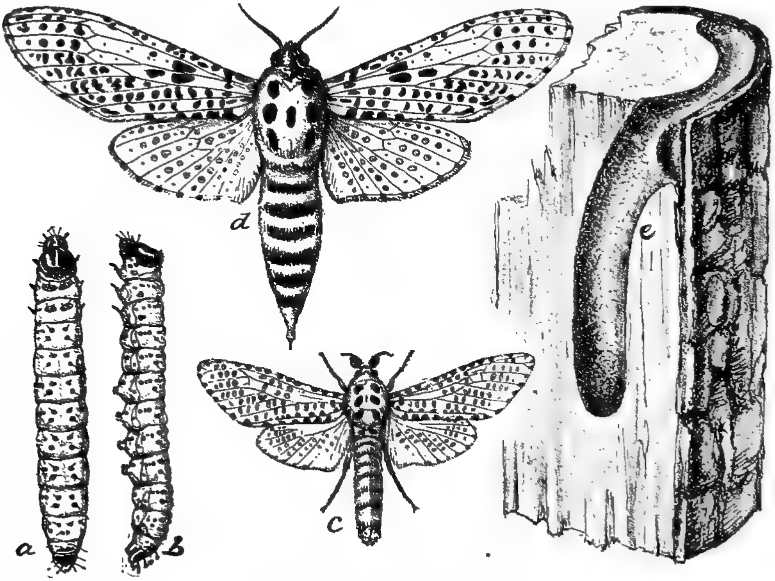

Fig. 16.

The wood leopard moth: *a*, *b*, boring caterpillar from above and side; *c*, male; *d*, female moth; *e*, shows the work of one of the borers. From Div. Ent., U. S. Dept. Agl.

it occurs. The period of flight begins during the last days of May and extends through June, July and into August. It is during the latter days of June and in early July that the insects are most abundant and the males are always most active around the lights. The females are heavily built and, when the eggs are developing, rarely move far from the trees out of which they were born and upon which they afterward oviposit. The eggs are small, salmon-pink in color, and may be laid singly or in masses, a single adult depositing between five hundred and one thousand or even more. They are usually placed in a bark crevice or other sheltered situation and generally on one of the smaller branches. The little caterpillar, when it hatches, makes its way to the crotch of a small branch, or to one of the nodes or buds and at once bores into the wood tissue. It works downward, toward the base, and grows very rapidly. When it is tired of its quarters, or when they become too narrow, the insect works out; sometimes directly, sometimes by cutting all around on the inside so that the twig breaks off. Then it makes its way further down, selects a larger branch and again begins feeding. Each individual seems to be a law unto itself as to the manner in which it feeds; it may bore a straight channel through the center of the branch, it may eat out a large cavity on one side, or it may deliberately work around and kill it. By the end of the first season the larva is half-grown and has usually made its way to one of the large branches, leaving behind it one or two that will be almost certainly broken by the winter winds.

During the second summer growth is rapid and the larvæ attain a length of two inches or more. On smaller trees they sometimes get into the trunk itself and may completely girdle it; or they may remain in the branches, or, in fact, work in almost any conceivable way, changing their location two or three times during the summer. At the end of this growing season they have reached their full size and, early in the spring following, work close to the surface and form pupæ, which, when the adults are ready to develop, wriggle their way out so that fully half projects beyond the bark when the moths emerge. The moths do not feed. The caterpillars do not feed upon the surface except for a short time, when they change their quarters and start in at a new place. There is no chance of reaching the moths through poisonous applications and practically no chance of reaching the larvæ by means of insecticides.

Thus far the insect has been confined to the cities, and while occasionally in the outskirts specimens are found in trees, it is the exception rather than the rule, and practically no injury is done in orchards or to the trees of smaller towns and villages. The larger the city the greater the injury, and the reason for that seems to be that in such places no birds, except English sparrows, are able to maintain themselves. Wherever this sparrow is not completely in possession the insect is no longer to be feared. In New Brunswick it is only in the very heart of the city that any injury is done, and even there it is slight compared with the trouble in Newark, Jersey City and Hoboken. Newark, whose population is most dense, also suffers most.

Remedial Measures.

Active measures are possible in one direction only. Every badly infested tree should be cut down and burnt, as its death is a mere matter of time at the best. Trees infested toward the tips only should be cut back in winter and the cuttings should be burnt. The openings to the burrows made by the larvæ are easily seen by the trained eye, especially during early summer, when the larva forces great strings of partly digested wood through the opening by which it entered. Where these burrows are in the trunks of valuable trees or shrubs, or in branches that cannot be easily spared, a few drops of bisulphide of carbon may be injected by means of an oil can or a small syringe, and the opening closed with a lump of putty. The vapor of the bisulphide will penetrate the full length of the tunnel and kill the larva, wherever it may be, without injury to the tree. Most of this work can be done during the winter. During the summer the trees should be kept under constant supervision, and wherever signs of borers are noticed the infested wood should be cut out, or the borer should be destroyed by means of the bisulphide of carbon.

There are undoubtedly natural enemies other than birds that tend to keep this borer in check. If the work of these natural enemies is supplemented by systematic work on the part of those in charge of the trees, a great lessening of injury will result. If in the public parks and squares in the cities other birds than sparrows could be introduced and protected, the work would be much simplified.

THE MAPLE TREE SESIID.

Sesia acerni, Clem.

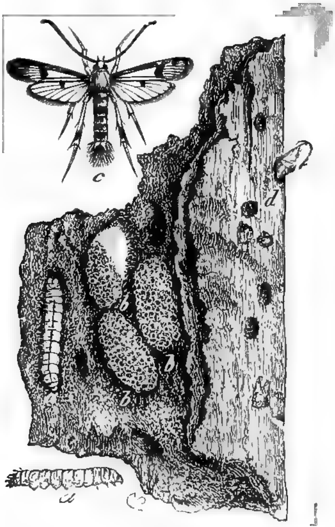

Fig. 17.
The maple tree sesiid: *a*, the larva; *b*, cocoons in cavities made by larva; *c*, the adult moth; *d*, pupa shell projecting from trunk. After Riley.

This is another caterpillar borer, found in soft maples more generally. It makes round holes, not over one-eighth of an inch in diameter, in the solid wood, and the caterpillar is white, or nearly so, with short, stiff hair on the surface. It comes to maturity in spring, and some time during the latter part of May or June forms its pupa near the outer surface of the trunk. When ready to change to the adult stage, the pupa wriggles out for about half its length, just as the pupa of the leopard moth does, and, usually very early in the morning, the moth emerges. This is rather a handsome little creature, yellow with red trimmings and bandings, the wings thin and transparent. It is one of the "clear wings" and looks more like a wasp than a moth. Sometimes maples are infested by a large number of these insects, but experience indicates that little real harm is done to the trees, provided water does not get into the holes to cause decay. The borings are in the heart-wood only, and as the heart-wood has little to do with the actual nourishment of the tree, there is no immediate weakening. Where the insects are observed in numbers it will pay to whitewash the trunks several times during the season. This will be effective—first, by repelling the moths that would otherwise oviposit on the trunks; and, second, it will cover over or partly fill the small holes that have been made by the insects. A tree once infested will, under ordinary circumstances, remain infested, and there seems to be an individual attraction that does not extend to even neighboring trees of the same species.

THE WHITE-MARKED TUSSOCK MOTH.

Orgyia leucostigma, S. & A.

The most common of the caterpillars found on city shade trees is that of the white-marked tussock or vaporer moth. It is pre-eminently a shade tree pest, rarely found in gardens and yet more rarely on trees away from cities and towns. In New York and Philadelphia it is *the* troublesome pest on streets and in the city parks. As we get into smaller towns and villages the pest becomes even less, until finally, in the country, it disappears almost altogether.

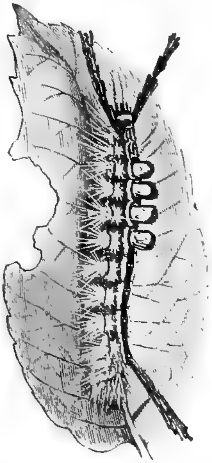

Fig. 18
Caterpillar of the tussock moth.

This caterpillar is recognizable by its bright red head and by the velvety black back, on which there are four thick tufts of creamy colored hair, looking like round paint brushes. At either end is a pair of long, black, plume-like hair pencils and there are shorter tufts of hair along the sides. In general, the caterpillars give the impression of being yellow, with black and bright red markings. They are first noticed in May, on practically all kinds of deciduous shade trees. When suddenly disturbed they drop, suspending themselves by silken threads attached to the leaves from which they started. They become full grown toward the end of June and then begin to wander, leaving the trees upon which they have fed, crawling to others some distance away, or along fences to gate posts, tree boxes or to any sort of shelter where, in some angle, they spin a loose, dirty, gray cocoon. The caterpillar has only a small supply of silk and with this it mixes hair from its own body, so as to make a more complete covering. In this cocoon the change to the pupa takes place and in about two weeks adults appear. The male has two pairs of dusty, gray wings, the anterior crossed by narrow, black lines and with a more or less prominent white spot toward the lower outer angle, the posterior without markings. The feelers or antennæ are broadly feathered and plume-like, while, when at rest, the tufted forelegs are extended straight forward. The expanded wings measure rather more than an inch from tip to tip.

The female looks entirely different; is without wings; somewhat slug-like, and consists principally of an abdomen distended with eggs. When she emerges from the pupa she crawls upon her cocoon, where she is found by the male, and to which she clings, almost motionless, for the balance of her life. Egg-laying begins soon after impregnation, the eggs being laid upon the old cocoon and covered with a frothy mass, which soon becomes hard, brittle, and is then snow-white. From this egg mass a second brood of caterpillars hatches in July and the life cycle is repeated, the second lot of adults appearing in September. The eggs laid at that time remain unhatched during the winter, and as the masses become wet and covered by dust, they gradually change to dirty gray or brown, losing their conspicuous character.

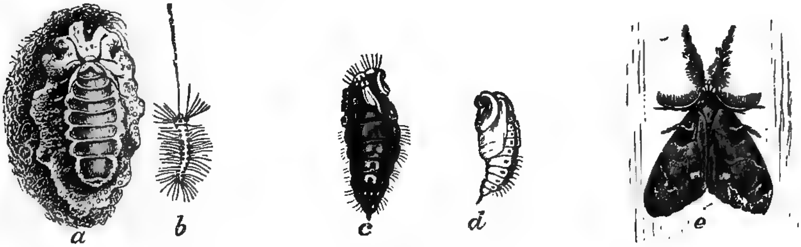

Fig. 19.

The white-marked tussock moth: *a*, the wingless female ovipositing on the empty cocoon; *b*, young caterpillar suspended by a silken cord; *c*, pupa of the female; *d*, pupa of the male; *e*, male adult or moth. After Riley.

It should be especially noted that the female is wingless; that she does not move from the place where she hatches, and that the only period in which the insects spread from one tree to another is in the larval stage, when either a mature caterpillar, in its wanderings in search for a place to pupate, climbs up the trunk, or when from some egg mass in the vicinity the young find their way to it.

Remedial Measures.

Whenever this insect appears in the garden, pick off the egg masses during the winter; they are readily seen and the task is not difficult. On shade trees the same method should be adopted wherever possible, and even a single tree may be kept clean in this way, provided the branches do not intermingle with those of another that is infested.

When the solitary tree has been once completely cleared of eggs, it can be kept clean by putting around the trunk, just below the branching, a broad band of cotton batting. This band should be tied near the bottom by a soft string that will yield to some extent to growth, and then should be turned down so as to form a sort of inverted funnel, making a barrier that cannot be surmounted by any caterpillar. A belt of tree lime, tree tanglefoot, or other sticky material will answer the same purpose.

If a tree is found to be badly infested, and it is desired to prevent defoliation, that may be done by spraying with any one of the arsenites. As to the strength and character of the material, reference should be had to the section dealing with insecticides.

THE BAG WORM, DROP WORM OR BASKET WORM.

Thyridopteryx ephemeræformis, Harr.

This curious insect is sometimes very troublesome and, unlike most other leaf-feeding caterpillars, attacks conifers as readily as it does all kinds of deciduous foliage. *Arbor vitæ* hedges are especial sufferers and are often killed when the insects have not been discovered in time.

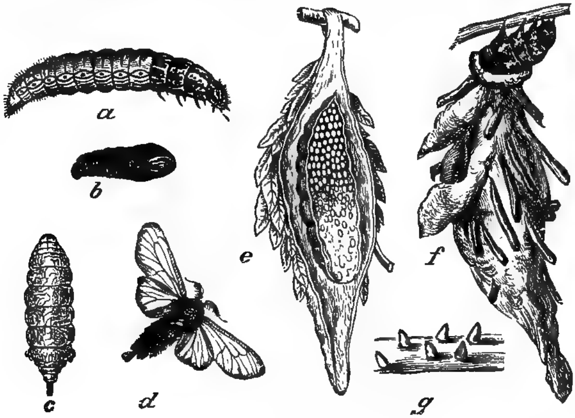

Fig. 20.

The bag worm: *a*, the caterpillar removed from its case; *b*, male pupa; *c*, female adult; *d*, male adult; *e*, a bag cut open to show the egg-mass as it appears in winter; *f*, caterpillar with bag of full size; *g*, very young larvæ with little conical bags carried upright.

The common name, bag worm, is derived from the fact that the larva is sheltered by a bag, basket or case, which it carries about as a shelter and in which it undergoes its transformations. These bags are often prominent objects on leafless trees and shrubs in winter, and, when closely examined, two distinct sizes may be noted. The smaller will be found generally empty, or with the remnants of a pupa shell only, while the larger will be found to be usually filled with a yellowish, powdery mass. If this larger bag is carefully cut open, we will find that it, too, contains the shell of a pupa; but filled with numerous small yellowish-white eggs, surrounded by a delicate, fawn-colored, silky down.

Some time in May, small, active caterpillars develop, which, after working out of the parent sac, at once begin to construct a bag or sac of their own. This little sac is made from bits of leaf tissue, fastened together with threads of silk to form a conical case, just large enough to contain the insect. At first it is carried upright; but as the larva increases in size and adds to the sac it becomes too heavy and is allowed to hang down and fastened to a twig or leaf by threads of silk when the insect is not actually moving. All sorts of fragments are used in making the sac; but whatever may be the outer covering, the inside is always lined with soft silk.

The young larva is uniformly brown; when fully grown that portion of the body covered by the bag is soft, light yellowish in color, while the head and leg-bearing rings, are horny and mottled with dark brown and white. The numerous hooks with which the small fleshy legs in the middle of the body are furnished, enable the larva to cling so tightly to the lining of the bag that it is with difficulty pulled out. When ready to transform to the pupal stage, the larva is seized with a wandering fit and travels for long distances, to other trees or shrubs, and thus provides for the spread of the species. Sooner or later a suitable place is found, the bags are attached to a twig or other support and the pupa is formed.

The bags from which the male moths are to issue become rather more than an inch in length, while those which are to produce the females reach nearly double that size. In both sexes the pupæ rest with their heads downward in the bag. In about three weeks the male works its way to the lower end and half way out of the bag, then its skin bursts and the moth appears—a small creature, with a black, hairy body and transparent, stumpy wings. It is swift of flight and, owing to its small size, transparent wings and short life, is rarely observed.

The adult female is grub-like, entirely without legs or wings. She pushes her way partly out of the pupa shell, her head reaching to the lower end of the bag, and there, without changing her position, she awaits the male. After impregnation she works her way back into the pupa skin, filling it with eggs as she again recedes. When all the eggs are laid she wriggles out of the bag for the first and only time in her life, drops to the ground and perishes. The elastic mouth of the bag closes after her and the eggs are thus securely protected until they are ready to hatch the ensuing spring.

Remedial Measures.

If these bags are noticed during the winter, there is nothing better than simply picking them off. *Arbor vitæ* and other coniferous plants should be especially attended to, because these do not survive defoliation. With a little practice the bags can be readily seen on even a thick hedge. On trees the matter is more difficult, but even there the work will pay, and if thoroughly done there will be no caterpillars of this kind during the season following.

If the insects are not noticed until summer, when they are at work upon the foliage, any of the arsenical sprays may be used, except on conifers, where only the arsenate of lead is safe.

THE FALL WEB WORM.

Hyphantria cunea, Drury.

This insect derives one part of its common name from the fact that the caterpillar makes a tent or web on the infested tree, and the other from the fact that it is much more abundant in late summer than earlier in the season. The winter is passed in the pupal stage, in a slight cocoon of silk intermingled with the hairs of the caterpillar. Early in May the adult makes its appearance, and is a snow-white moth or miller; the anterior or fore wings often more or less black-spotted. During the day it may be found resting on trees, tree boxes, fences or even on leaves; but during the night it flies readily, and during that time the female lays her eggs. These eggs are placed in one mass on the under side of a leaf, ranging from four to five hundred; each egg bright yellow in color, nearly spherical and ornamented by numerous regular pits. In about ten days they hatch and the caterpillars at once spin a little tent for their common shelter. As they increase in size they draw in more leaves, twigs, and sometimes even branches, so that the nest may become from two to three feet across in its largest dimension.

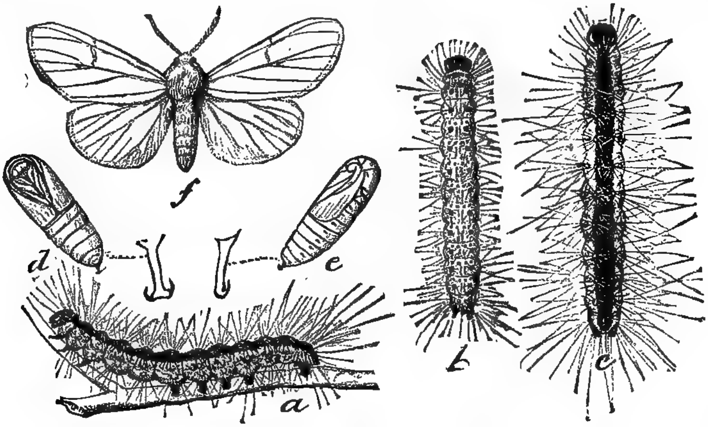

Fig. 21.

Fall web worm: *a*, caterpillar from side; *b*, *c*, same from above, showing variations; *d*, *e*, the pupa from front and side; *f*, the adult moth. From Div. Ent., U. S. Dept. Agl.

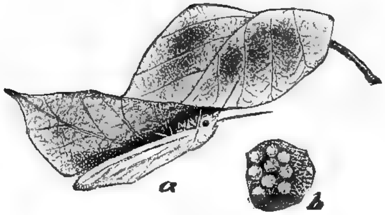

Fig. 22.

Female laying eggs; individual eggs enlarged at *b*.

The first brood is rarely abundant enough to attract much attention, and the nests seem to be smaller than those found later in the season. Early in July caterpillars are full grown, leave the nests and make cocoons in any convenient shelter nearby. Moths issue in a few days and shortly afterward are ready to lay eggs in turn.

When the second brood appears, in July or early August, the tents are so much more numerous that they attract more attention and the insects grow so fast that unless measures are taken at once the infested trees may suffer defoliation. The nest or tent is a shelter merely, and from it the caterpillars work out to feed in every direction, returning to rest at certain periods of the day. Late in August and during the first half of September the larvæ of the second brood leave the nests and wander, sometimes for considerable distances, before they change to the pupal stage.

The first brood seems to suffer little from parasitic attack, and most of the caterpillars complete the change to the adult condition. The second brood is, as a rule, greatly parasitized, and a very small percentage of the specimens that become full grown complete their transformations. This accounts for the fact that the spring brood is usually a small one, and also for the fact that sometimes, when conditions favor the caterpillars rather than the parasites, the species runs away from its checks and for a year or two will become plentiful enough to do considerable mischief.

Remedial Measures.

In the garden this insect is readily controlled. As soon as the first trace of a nest is noted it should be torn out and the entire brood killed. As the tent then takes in only one or two leaves this is an easy matter, and there is no danger of mutilating any tree or shrub.

On shade trees, where the nests cannot be readily gotten at, the foliage at the points where the nests are observed should be sprayed with an arsenical poison. There is no necessity for spraying the entire tree, because the insects feed only in the immediate vicinity of the nest so long as there is anything to eat at that point. If the second brood becomes abundant and nests are seen all over the tree, then, of course, the entire tree should be sprayed. The caterpillars succumb very readily to arsenical poisons while they are still small; therefore, the earlier the spraying is done, the less the foliage will be eaten and the more easily will the insects be destroyed.

THE ELM-LEAF BEETLE.

Galerucella luteola, Müll.

This insect is confined in its attacks to elms, and prefers the European to the American varieties. The winter is passed in the adult condition and the adult is a beetle, about one-quarter of an inch in length and less than half that in width, dull yellow in color with a black stripe on each wing-cover. These adults begin to show themselves about the time the first elm leaf approaches full size, and immediately feed, eating irregular holes through the leaf tissue. If the beetles are at all numerous, the foliage, by the time that it is fully out, will appear as if loads of shot had been fired through it in every direction. During the latter part of May and in early June, bottle-shaped eggs are laid on the under sides of the leaves,

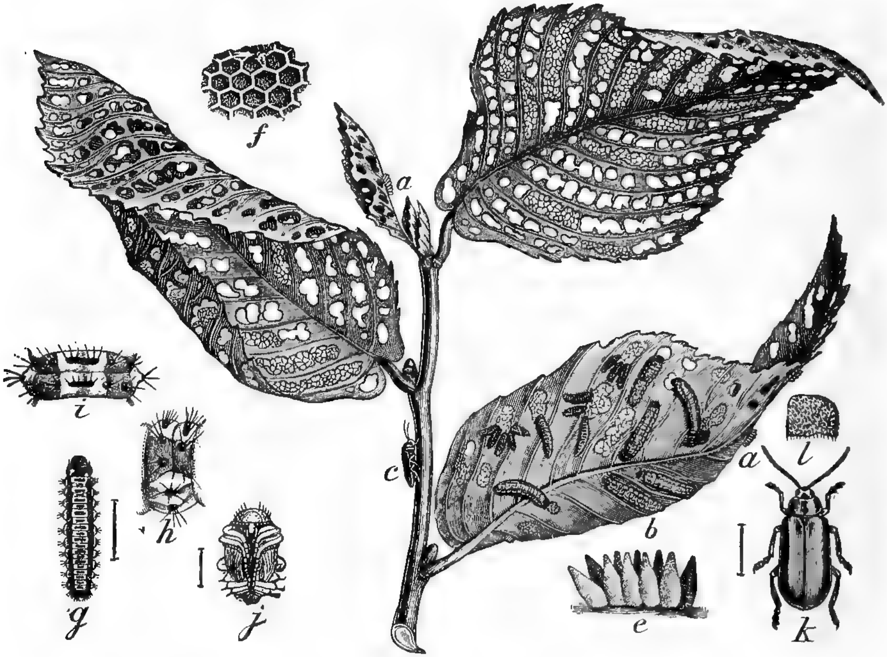

Fig. 23.
The elm-leaf beetle: *a, a,* egg patches on leaves; *b,* larvæ feeding; *c,* adult; all natural size; the holes eaten through the leaves are by the adults, the scraped surfaces are by the larvæ; *e,* egg mass; *f,* surface of an egg; *g,* larva; *h, i,* larval details; *j,* pupa; *k,* beetle; *l,* surface of elytra; *e* to *l* enlarged. From Div. Ent., U. S. Dept Agl.

arranged in a double row in groups of from twenty to forty. The first larvæ appear about June 5th, and others continue to hatch from the egg masses until after the 20th of that month. These larvæ are yellowish, slug-like creatures, with black dots and tubercles that are set with bunches of short bristly hair. They usually feed on the under sides of the leaves and do not eat through the tissue—they take only the lower layer of cells and therefore scrape rather than eat. The result is that, for a time, the leaves retain their form and appearance, and not until the larvæ are nearly full grown does injury become greatly apparent. Then the foliage begins to turn brown and very suddenly the tree looks as if a fire had swept through it.

Beginning during the last days of June and continuing until the middle of July, larvæ crawl down the trunks to the base, and there, among the grass on the surface of the ground, they change to yellow pupæ. Many of the larvæ do not come down all the way, but get into the bark crevices and in such shelter change to the pupal stage. Adults develop about a week after the pupa has formed, and, usually about the beginning of August, the summer brood of beetles is found most abundantly. In the latitude of New Brunswick, and in New Jersey generally, there is only a partial second brood or none at all. Ordinarily, the beetles that hatch in summer feed for a few days and then gradually disappear. By the middle of August nothing more is seen of them and, as a whole, they are in hibernating quarters, from which they will not again emerge until spring of the year following.

This insect has few natural enemies among the predatory or parasitic forms; but during the few years last past has been attacked during the latter part of each summer by a disease which killed off full-grown larvæ and pupæ in enormous numbers. For a time elm trees in certain cities and throughout a large portion of the State were annually defoliated to such an extent that many were killed, and it became a question whether it was not really cheaper to cut them out and plant other trees rather than treat with insecticides. That the insects could be kept in check was proved by work done not only at New Brunswick but in other portions of the State; and on the college campus the large elms were sprayed each year for several years in succession. Then the disease already mentioned seemed to establish itself more firmly each year, and for the three years last past it has not been necessary to make insecticide applications.

Whether this control is a permanent one, or whether, under favorable conditions the insects will again become injurious, it is impossible to say. At all events it is advisable for those who have charge of elm trees to watch this beetle closely, and if at any time the number found feeding in early spring is sufficient to make it probable that injury will be caused, prompt action should be taken.

Remedial Measures.

As this insect is a feeder upon leaf tissue, arsenites are indicated, and, as a matter of fact, have proved themselves effective. Paris green has been most generally employed and, at the rate of one pound in one hundred and fifty gallons of water, forms a satisfactory remedy. Arsenate of lead, at the rate of one pound in seventy to seventy-five gallons of water, has also been used to good advantage and is preferable because of its greater lasting qualities. In any case where the insect is to be dealt with by insecticides, a spraying should be made as soon as the first feeding by the adults is noticed. This spraying is very important, because, if the beetles can be killed off before they lay eggs, there will be no larvæ to deal with later. As both sexes hibernate and the ova develop after the beetles have begun to feed, there is a period of a week or ten days during which they may be reached before egg-laying begins. Where only a few trees are to be looked after, a second spraying, made about a week after the first, is desirable. The reason is that the foliage at that period develops so fast that a week after the treatment there will be an abundance of new leaves upon which the beetles may feed safely. If it becomes necessary to deal with the larvæ, spraying may be delayed until hatching from the eggs is quite general; then the application should be made very thoroughly, and it is now important to reach the undersides of the leaves, rather than the upper. The beetles eat the entire leaf tissue and it makes no difference whether the poison is on the upper or on the under surface. The larvæ eat only the lower layer of cells, and, even if the upper surface be fully covered by the arsenical poison, they may not get even a particle. It should be emphasized, then, that whenever a spraying is made, having for its object the destruction of the larvæ, every effort should be made to reach the under side of the foliage. It is the neglect of this point that has resulted in the lack of satisfactory results in many cases.

SLUGS.

Under this general term the gardener usually recognizes caterpillar-like creatures that feed upon his roses, currants and sometimes pear and cherry foliage.

The currant slug is well known and when unchecked defoliates the plants completely, leaving only half-grown or ripening fruit, without a trace of shelter. On roses the foliage is scraped, the leaves turn brown, shrivel, and the plants lose their beauty in proportion to the number of insects that feed upon them. The currant slug is green, with large black spots, and has the habit of curling the end segments of the body around the edge of the leaf. The rose slugs are green, as a rule, without obvious spots, and, while there are some that have much the same habits as those found on the currant, there are others that feed on the upper surface only and are fully extended.

On pear and cherry the upper side of the leaf is scraped and the slug is blackish-brown or very dark olive green, without spots or marks, viscid or gummy in appearance and to the touch. The parents of these slugs are saw flies, and are inconspicuous, transparent, winged insects, rarely seen by the gardener. There is quite a variation in the life history, but as the life history does not aid us in the control of these species it will not be necessary to go into detail.

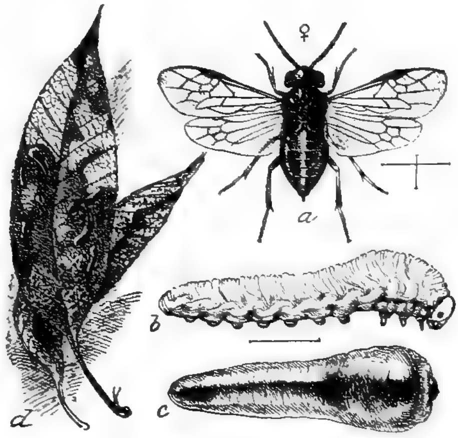

Fig. 24.

The pear slug, *Caliroa cerasi*: *a*, adult; *b*, *c*, larva from side and above; all enlarged; *d*, leaves eaten by the larvæ. From Div. Ent., U. S. Dept. Agl.

All these slugs or saw-fly larvæ are peculiarly susceptible to the action of white hellebore, and a decoction of white hellebore is the most usual remedy to be applied. The decoction is made by steeeping an ounce of the powder in a quart of boiling hot water and adding sufficient cold water to make one gallon of spraying mixture. Thoroughly applied this will kill any of the slugs in short order. It is a contact poison and loses its effectiveness in a short time. It is essential, therefore, that it shall be used when quite fresh, and that it shall reach all the insects that may be feeding upon the plants.

A better and more lasting remedy is the arsenate of lead. This may be safely applied to the foliage of any garden plant likely to be infested, and once sprayed the foliage will remain safe for a long time. All the slugs succumb readily to arsenical poisons and complete exemption from trouble may be easily secured. None of the ordinary shade trees are subject to destructive attacks by larvæ of this character.

INSECTICIDES.

As against those insects that feed upon plant tissue and are to be reached through the stomach, there is nothing better than arsenic in some form. Paris green is the poison most generally employed and is, on the whole, the cheapest and most easily available. Paris green of good quality contains about sixty per cent. of arsenic, combined with copper in such a way as to be practically insoluble in cold water and only sparingly soluble in warm water. By adding one pound of lime when the Paris green is mixed up, the remaining free arsenic is combined. It may be used with safety on deciduous shade trees of all kinds at the rate of one pound in one hundred and fifty gallons of water. It may be used on most fruit trees at the same rate, but on peach and plum is apt to cause injury. It should not be used on tender garden plants and must not be used on conifers of any kind.

The safest arsenical poison is arsenate of lead. It may be purchased in paste form in one-pound (or larger) boxes, and is harmless to all sorts of foliage at any reasonable strength. At the rate of one pound in fifty gallons of water it kills practically all leaf-feeding insects, and may be used on even conifers with absolute safety. Against most leaf-feeding insects one pound in seventy-five gallons of water will prove satisfactory, and, used at that strength, its cost is about double that of Paris green. Its advantages are harmlessness to foliage, which makes it safe to give into the hands of careless laborers, and adhesiveness, remaining upon the foliage a longer time than any other of the stomach poisons. On the whole, therefore, arsenate of lead is recommended, not only for the garden, but for shade trees in cities, towns and villages. Under ordinary circumstances it is better to buy the arsenate in paste form, ready made. Where much of it is to be used and where an intelligent man superintends the work, a considerable saving may be effected by mixing the raw materials as needed. Arsenate of lead is a combination of arsenate of soda (four ounces) with acetate of lead (eleven ounces). These materials should be separately dissolved in wooden pails, in water enough to do it completely. Then one solution may be poured into the other, stirred thoroughly for a few moments and the combination is arsenate of lead. If allowed to stand, a white precipitate will settle to the bottom, and represents the poison itself. If the combination is diluted to make from fifty to seventy-five gallons of water, the settling will be slow, and practically the entire material may be sprayed without any stirring. That is another advantage, because one part of the mixture will not be very poisonous and another practically harmless, as is likely when Paris green is used and the mixture is not kept sufficiently stirred. It is important, if the arsenate of lead is to be made as used, that the chemicals employed should be of good quality. This point must be insisted upon, because failures have resulted from impure chemicals. The acetate of lead is especially liable to contain substances that will interfere with proper combination.

As for contact poisons, fish oil soap will reach more cases than any one other material, and in most instances it will pay to buy the soap ready made up. There are several brands on the market that answer every purpose, and almost every dealer in insecticides has some reasonably good material of this character. If it is desired to obtain the cheapest mixture and to be absolutely certain of an even composition, the soap may be readily made according to the following formula, first recommended by the New York (Geneva) Station:

Caustic soda.................	6 pounds.
Water	1½ gallons.
Fish oil.....................	22 pounds.

Dissolve the caustic soda in warm water, warm the oil until it is thoroughly fluid, then pour the oil slowly into the soda solution, stirring thoroughly and constantly until the combination is complete. Complete and thorough stirring is essential to success. A good grade of caustic soda should be used, say 75 per cent. or over. Fish oil of almost any kind will answer and it need not be refined. The amounts given will make forty pounds of soap, and the cost, at the market price of materials, will be a trifle less than 3 cents per pound. Twenty-two pounds of oil is about three gallons, so that a full pint, or a little over, may be considered the equivalent of a pound of oil. If a slight excess of soda is used no harm will be done. This makes a soft soap, but though when warm it stirs readily, when cold it forms a stiff, cheesy mass. The soap made according to this formula is stronger than most of the fish oil soaps on the market, and, as against most green plant lice, may be used at the rate of one pound in seven gallons of water. After it has been tested and the proper strength for the different insects has become known to the user, it may be relied upon to do the same work every time when made in the same way. It is, of course, possible to make smaller quantities if desired; the proportion being held carefully. Where it is necessary to summer-spray shade trees to kill scales or plant lice, this will prove the cheapest and most reliable contact poison that can be used.

Where the San José scale must be dealt with in the garden, there is, perhaps, no better material on the market at present than "Kill-O-Scale." This is a preparation of petroleum made soluble in water and is one of the most active contact insecticides that we have. Any other soluble petroleum would probably answer as well, and while these preparations are rather expensive, they have the advantage of being always ready and requiring nothing except a simple dilution with water when the application is to be made.

Tobacco has been already referred to in connection with the treatment of plant lice and its range of usefulness is there explained.

For the gardener arsenate of lead and fish oil soap are really all that are necessary. When large trees are to be dealt with, Paris green may be substituted for the arsenate of lead, although the latter is preferable, and fish oil soap or soluble petroleum will prove most useful where contact insecticides are needed.

Undiluted crude oil has been referred to and is the most effective contact insecticide that we have. Unfortunately, its use is attended by considerable danger to the tree if it be not carefully applied. Nevertheless it is sometimes advisable, or even necessary, to employ it, and in such cases danger may be reduced to a minimum—*first,* by using oil having a specific gravity of at least 43° on the Beaumé scale—the insecticide oil supplied by the Standard Oil Company is such an oil; *second,* have the oil slightly warmed, say 70° to 80°, so that it will spread well; and, *third,* apply in a very fine spray, just enough to cover. Applied with an atomizer, the oil is almost always safe in careful hands; but it will not do to intrust it to an ordinary laborer.

The lime, salt and sulphur wash has also been referred to in connection with the San José scale; but this is not advised for garden use and is not needed for use on shade trees. If there are trees infested by the San José scale in such numbers as to require a large quantity of material, this wash may be needed, and in that case full directions for making and applying will be found in Bulletins 169 and 178 of the Station; either of which may still be had.

INSECTICIDE MACHINERY.

At present it is possible to buy machinery to spray a single bush or the tallest tree. There are bucket pumps, syringes, atomizers and anything from these to power sprayers, giving pressure to any desired extent. In the garden, a compressed air sprayer is on the whole the most convenient. Such sprayers, holding from one to five gallons of liquid and working by means of a pump that compresses the air above the material to be sprayed, are very practical and will serve to deal with all ordinary garden plants, shrubs or even small trees. A five-gallon Leggett sprayer has served for the experiments in my own garden, and other advertised machines of the same capacity are as good. The nozzles attached to such outfits usually leave much to be desired, and in general it will pay to take off those that are furnished and substitute a Vermorel, that will give a fine and abundant spray. Where roses, small fruits and other low plants only are to be dealt with, an even simpler outfit will answer. Atomizers are now made with cans holding one to two pints of mixture and making an extremely fine spray in practical use. In many gardens that will be all that is needed and the cost amounts to only a dollar or two. It will pay to buy one made of brass and of good quality throughout. Where a bucket pump or anything above it is used, the Vermorel nozzle should be made a part of the outfit, and, in general, it may be said that it does not matter so much what the pump is, provided it gives a reasonably constant pressure—if the nozzle makes a fine spray with force enough to penetrate through the covering of protected insects or the pubescence on the surface of some leaves. A sprinkling pot is the poorest thing that can be used, because the particles from the rose are so coarse that they will either roll off without wetting leaf or insect, or will waste at least as much material as is actually effective. Every seedsman nowadays has pumps and atomizers, and most of the reputable dealers can be relied upon to recommend only those that are at least workable.

When the matter of dealing with large trees comes under consideration an altogether different kind of outfit is needed, and it is practically impossible to make recommendations that will serve for all communities. The very fact that almost every maker of pumps has some special outfit meant to deal with such trees makes it difficult to recommend one particular type. In general, any pump or outfit that will be satisfactory in the orchard will be equally satisfactory on shade trees in cities; but, on the whole, shade trees are larger than orchard trees and some machines that serve very satisfactorily in the orchard are either clumsy or otherwise objectionable in city streets. Where only a few trees are to be treated, a good pump working by a vertical lever, giving a pressure of one hundred pounds to the inch, will prove satisfactory. The suction pipe of such a pump may be arranged so as to draw from either a tank or barrel, or so as to be placed into half a dozen barrels in succession, if the spraying wagon will hold that many. There should always be a strainer at the end of the suction hose so as to prevent particles that will not pass through the nozzle from getting into the pump at all. An air chamber of good size is always desirable to maintain an even pressure, even if pumping should stop for a short period. Valves should be metal, or at least of some material that will not require frequent packing. The working parts should be of brass and should be kept as clean and well oiled as possible, to prevent corrosion. Where caustic mixtures are to be used to any considerable extent, the pump should be especially well looked after and should always be washed out after a spraying to prevent wear. When it becomes necessary to deal with a large number of large trees in a city or town, it will be always necessary to get an outfit especially adapted, and power will be advisable. In such cases each community will obtain just that machine which will answer its own purposes best and no specific recommendations can be made. So many considerations will enter into account that what will answer for one municipality may not be satisfactory for another.

I have recommended for several of our communities the "Niagara sprayer," power for which is furnished by liquid carbonic acid gas. This requires no special skill to operate, is noiseless, gives an even pressure and the pressure may be promptly raised to any point necessary to secure satisfactory results. I do not say that it is the best machine for all purposes; it is a good machine for many purposes. It is suggested that when any community having a considerable number of trees to deal with desires to secure an outfit, it communicate with the Experiment Station and obtain such information as may be needed.

In every case the nozzle is the most important part of the outfit. There must be sufficient power, but there must also be the nozzle which is capable of throwing a fine spray with enough force to cover a reasonably large surface. Nothing known to the writer is better than the Vermorel nozzle, or some one of the modifications that work on the same principle.

CLASSIFIED LIST OF SHADE TREES.

The following list of shade trees, based on that prepared by Mr. B. E. Fernow, chief of division of forestry, U. S. department of agriculture, for the Brooklyn Tree Planting and Fountain Society, is arranged in the order of least susceptibility to insect attack, though none are entirely exempt. It is not intended to suggest that they are the best in the order named, except so far as freedom from insect attack in New Jersey is concerned. Dr. Halsted has kindly marked the list for fungous troubles, and the numbers in parenthesis following the names indicate the order of their freedom from disease, No. (1) indicating the species least affected.

Tree of Heaven (Tallow tree). *Ailanthus glandulosus.* (3.)
Ginko, or Maiden-hair Tree. *Ginkgo biloba.* (1.)
Sweet Gum. *Liquidamber styraciflua.* (2.)
American Linden. *Tilia americana.* (7.)
European Linden. *Tilia vulgaris.* (8.)
Small-leaved Linden. *Tilia microphylla.* (9.)
Tulip Tree. *Liriodendron tulipifera.* (6.)
Cottonwood Poplar. *Populus monilifera.* (19.)
Horse Chestnut. *Æsculus hippocastanum.* (18.)
Oriental Plane Tree. *Platanus orientalis.* (20.)
American Plane Tree. *Platanus occidentalis.* (21.)
Box Elder. *Negundo aceroides.* (10.)

All oaks. *Quercus* Sp. (11.)
All maples. *Acer* Sp. (12.)
All willows. *Salix* Sp. (13.)
American Elm. *Ulmus americana.* (17.)
Slippery Elm. *Ulmus fulva.* (16.)
Scotch Elm. *Ulmus montana.* (15.)
European Elm. *Ulmus campestris.* (14.)
Black Locust. *Robinia pseudacacia.* (5.)
Honey Locust. *Gleditschia triacanthos.* (4.)

Bulletin 122

February, 1906

NEW HAMPSHIRE COLLEGE

Agricultural Experiment Station

IN COÖPERATION WITH THE

State Board of Agriculture

SECOND REPORT

The BROWN-TAIL MOTH

IN NEW HAMPSHIRE

THE WINTER WEB.
CUT AND BURN IT!

By E. DWIGHT SANDERSON

Entomologist to the Station and State Nursery Inspector

NEW HAMPSHIRE COLLEGE
OF
AGRICULTURE AND THE MECHANIC ARTS
DURHAM

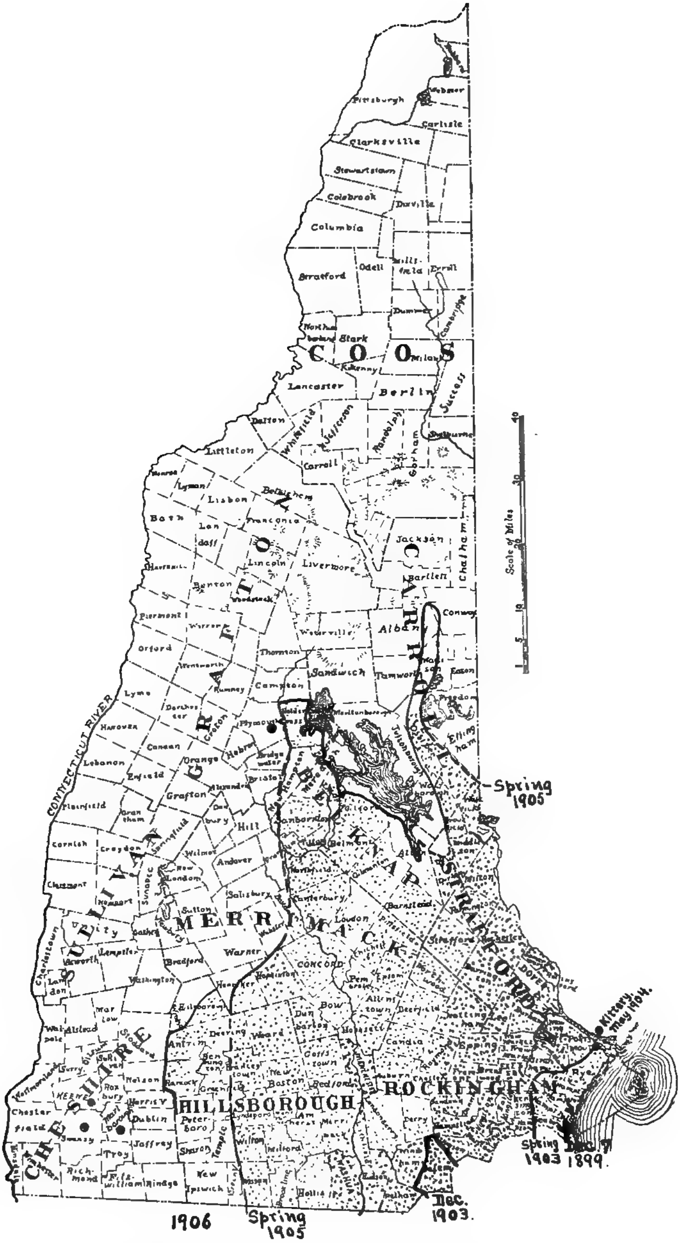

FIG. 1.—Map showing the gradual spread and distribution of the Brown-Tail Moth in New Hampshire. Dotted area infested in 1906. Heavy lines indicate outer boundaries of areas infested in years indicated at margin. Dash lines represent approximate boundaries not personally investigated, based on points infested north of these points. Black circles show points examined in January, 1906, and found uninfested.

THE BROWN-TAIL MOTH.[1]

HISTORY.

The brown-tail moth was probably introduced into this country at Somerville, Mass., on nursery stock imported from Europe about 1890. Not until 1897 did it attract the attention of the Massachusetts Gypsy Moth Commission, whose agents thoroughly investigated the pest. No funds were then available for controlling it, though the Legislature passed a law "requiring the local authorities to suppress the brown-tail moths," and the Massachusetts Board of Agriculture determined its spread. In 1898 the work of controlling this insect was placed in the hands of the Massachusetts State Board of Agriculture, with $10,000 of the funds appropriated for the gypsy moth available for such work. Since that time the control has been in the hands of the local authorities.

In Europe this is one of the oldest and best known of the caterpillar pests, being called the "common caterpillar." It has been known there since the times of the earliest writers upon insects and natural history, excellent accounts of it having been written nearly three centuries ago. It is common over Central and Southern Europe, Western Asia and Northern Africa, and extends north into Sweden.

SPREAD AND DISTRIBUTION.

Occurring over a dozen towns when first recognized in 1897 and there being at no time a well-organized effort having sufficient funds for its control, the pest spread rapidly and in December, 1899, the first of its winter nests was found in New Hampshire, at Seabrook. Its spread since that time is approximately shown on the map, figure 1. Portsmouth and the coast towns became infested in 1901 and 1902 and in the spring of 1903 they were found to comprise the infested area in New Hampshire, with the exception of the southern part of Stratham. In December, 1903, no nests were found in Atkinson, and but few in Salem, N. H., along the Massachusetts line, they becoming scarce and disappearing northward in Salem, thus showing that the pest had not spread much over the line west of the eastern part of Rockingham County. The greatest spread occurred in 1904 during the summer flight of the moths in July. On Saturday, July 9, the moths invaded Nashua in immense swarms, so that the electric light posts and wires were white with them and they were reported in large numbers on all the principal streets by the police. At Newmarket they appeared on July 12, "by the million," according to Mr. Pinkham of *The Advertiser*, who stated that two quarts of the dead moths were taken from one arc-light globe and the front of a church was covered as if by a snowfall. On July 22 but few moths were to be seen in Newmarket. Further north the moths do not seem to have appeared in such numbers, though Manchester, Concord and Rochester became well infested. The spread in 1904 was the greatest recorded, the northernmost infested points being North Conway and Holderness, representing a spread of some seventy-five miles in that season, undoubtedly occurring during the flight of the moths. The exact spread in the southwestern part of the state was not determined as definitely as was desired, but there seemed to be but little infestation west of Concord. Inspections made by assistants of this office showed that Contoocook and Henniker were slightly infested, but Warner and Hillsborough were not. Specimens were received from several towns south and slightly east of these.

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[1] *Euproctis chrysorrhœa* L.

In February, 1904, this station issued a warning bulletin on the brown-tail moth by Dr. C. M. Weed, so that the public was well informed concerning it. In January, 1905, in coöperation with the state board of agriculture, a poster was circulated throughout the infested portions of the state, considerable attention was given the matter by the press, granges, schoolteachers and others, so that everyone was awake to the necessity of controlling the pest by removing the winter webs. As a result the webs were very generally destroyed throughout the southern part of the state, this being aided with appropriations by many of the towns. To this effective work is undoubtedly due the fact that there was not more spread in 1905. Examination made by my assistant, J. L. Randall, shows that the northernmost limits of infestation have not been extended, though rather more webs are found at Laconia and other towns in that latitude, while to the southwest only one row of towns further west were found to be infested as far as we have been able to determine from a hurried inspection, including Hancock, Bennington and Antrim. Keene and Marlborough seem to be uninfested. Reinfestation has undoubtedly taken place from the southern part of New Hampshire and Massachusetts by moths flying northward during the past summer, for in many places the infestation is more serious in January, 1906, than in January, 1905, though the nests were carefully removed very generally over the towns. This is noticeably so in Durham. This but emphasizes the necessity for requiring all towns to control the pest within their borders.

LIFE HISTORY.

The Winter Webs, or Nests.—During the winter the well-known webs of the brown-tail moth caterpillars are to be found on the tips of the twigs of fruit and shade trees. Typical examples are shown in figure 2.

These webs are usually about three or four inches long, composed of leaves woven together with silk, which forms a firm, tough web. The whole nest is often attached to the twig by the stems of the leaves, which have been worked into it, the stems being wound round and round with silk and this being continued onto the twig, as shown in the figure. If a nest be torn open it will be found to contain numerous little round, white, silky masses, looking like

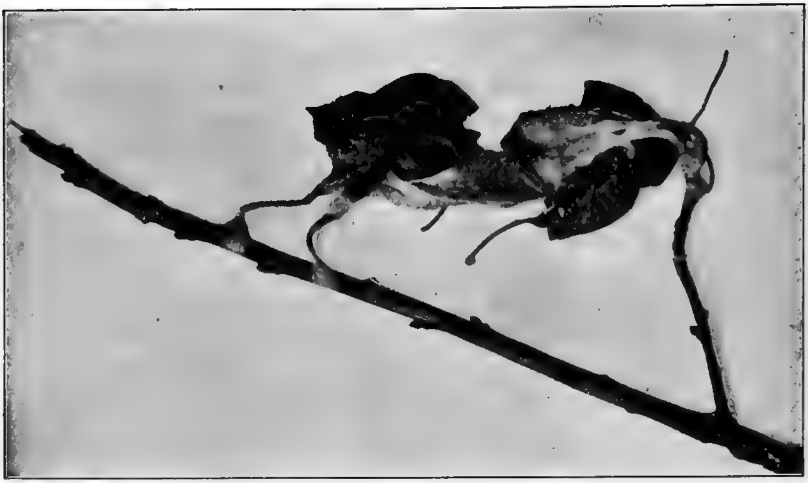


FIG. 2.—Winter web of the Brown-Tail Moth. (After Weed.)

spider's eggs, each of which contains two to a dozen small, brown, hairy caterpillars about one-sixth of an inch long (Fig. 3). At one side or lower end of the web is found

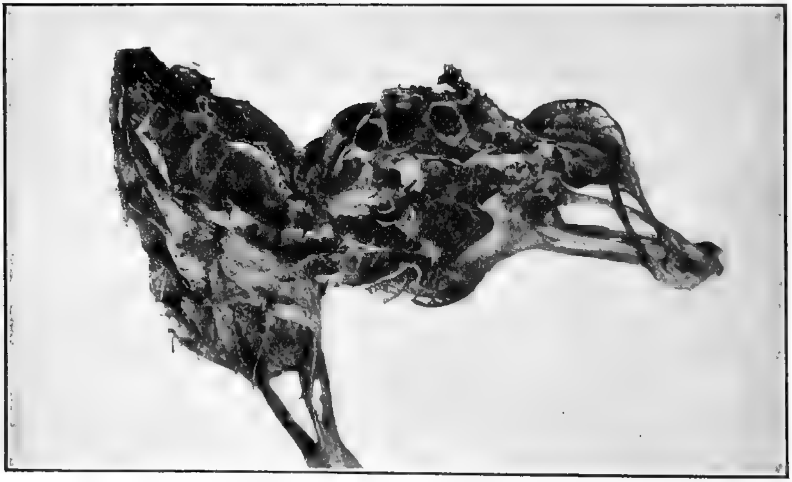


FIG. 3.—Winter web opened to show the different compartments or cells, each containing young caterpillars within.

a mass of black exereta and the cast skins of many of the small caterpillars, for during the warm days of fall the caterpillars feed more or less upon the dead leaves composing the web, and many of them molt in the web. Thus the leaves of the web often become pretty well skeletonized.

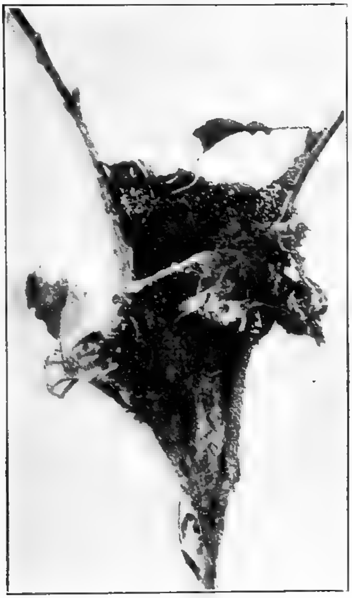


FIG. 4.—Old web of tent caterpillar.

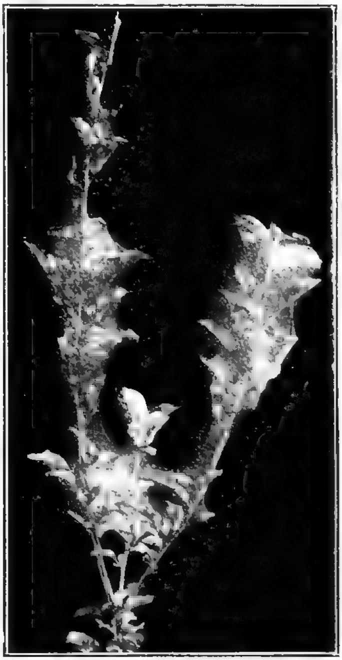


FIG. 5.—Web of fall web-worm covering foliage. (After Weed.)

There are no other webs common on trees which may be mistaken for these. Any webs containing small caterpillars in winter are those of the brown-tail moth. The tent-caterpillar and fall web-worm both make webs which often remain on the trees over winter, but they are weatherworn, thin webs, with no caterpillars, and are much larger. The curled elm leaves caused by the elm aphis often remain on the trees over winter and may prove misleading to one

FIG. 6.—Elm leaf curled by aphis. (From Weed.)

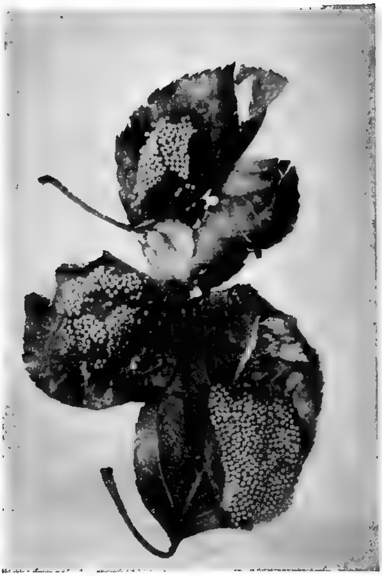


FIG. 7.—Eggs of Rusty Tussock Moth.

whose eye is not trained to detecting the brown-tail webs. The eggs of the rusty tussock moth frequently found on fruit trees, especially plum, are often brought in for the eggs of the brown-tail where bounties are paid for its webs, but as the brown-tail's eggs are laid only in summer there should be no confusion.

With the warm days of late April and early May the little caterpillars emerge from their winter's home, the balance of which they often devour before going to the opening buds, upon which they feed greedily. The first emergence noted in Massachusetts was on March 18, 1898, the 29th of April being given as about the last of their appearance. In 1905 the first caterpillars emerged at Durham on April 21 and continued to emerge until May 10, the largest number emerging on May 6, thus commencing to appear about the time the maximum temperature reached 60° Fahr. and the maximum emergence taking place about the time the maximum reached 80° Fahr. A record of the caterpillars emerging from 10 nests of average size gave an average of 375 per nest, the largest number being 444 and the smallest 172. The webs vary greatly in size, however, as Fernald and Kirkland found as few as 47 and as many as 802 in a single web.

An examination of the caterpillars in five winter webs made during the winter of 1905 showed an average of about 25% dead. After the remarkable warm weather of January 21–23, 1906, a careful examination of nine nests was made, having an average of 220 caterpillars each, of which 10% were dead, the smaller mortality possibly being due to the mild winter up to that date.

It seems quite probable that were a few unusually warm days to occur in early spring, so as to cause the caterpillars to leave the webs, followed by a sharp freeze, that many of them might be killed, as were the forest tent caterpillars in 1900 (see Bulletin 81, *p.* 11). Considerable comment has arisen in the

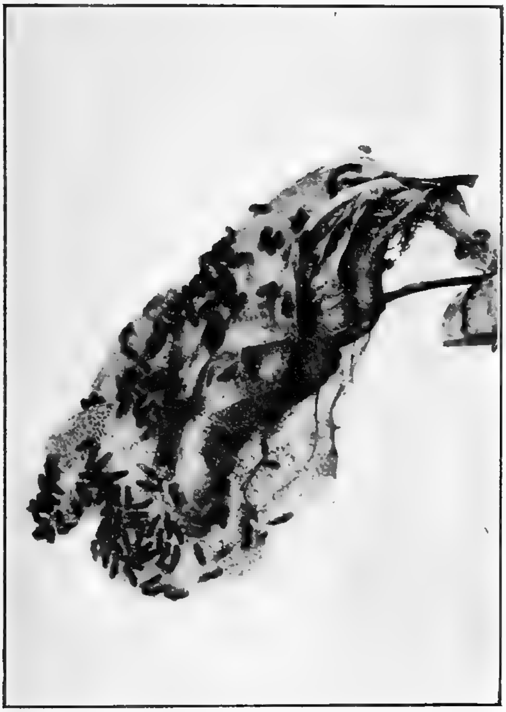


Fig. 8.—Small Brown-Tail Moth caterpillars emerging from the winter web and feeding on the leaves of its surface.

daily press concerning the effect of the warm weather of January 21–23, 1906, upon the caterpillars, some stating that they had emerged from the webs. As far as we have been able to observe none of the caterpillars emerged at that time. The influence of the unusual temperature conditions is now being studied by us, by determining the mortality of the caterpillars in the webs at different periods during the winter. Had the warm weather been followed by a very sudden low temperature, the effect upon the caterpillars would more probably have been fatal. Various experiments upon this point were conducted last winter and are being continued, but are not at present conclusive.

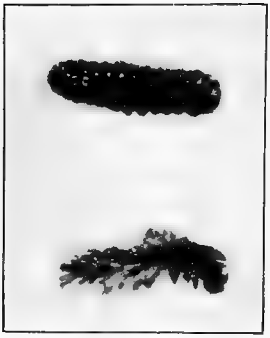


FIG. 9.—Young Brown-Tail Moth caterpillars, just from nest; 4 times natural size.

When they first emerge from the winter nest the young caterpillars (Fig. 9) are of a blackish color covered with warm-brown or reddish-brown hairs. The head is jet black, while the body is marked with yellow when seen under a lens. Projecting from the back of the fourth and fifth segments is a large tuft of reddish-brown hairs, looking like a brush, and about two thirds the height

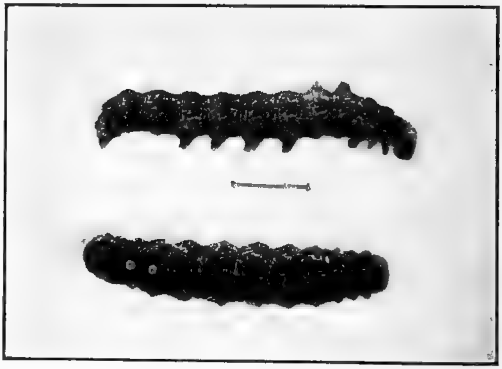


FIG. 10.—Second spring stage of the caterpillar, enlarged 4½ times; natural size shown by line.

of the body. On the middle line of both the ninth and tenth segments is an orange or coral-red retractile tubercle. These details may be seen in figure 9. In about eight days the caterpillars shed their skins or molt, after which they are about two fifths of an inch long (Fig. 10), the body hairs are relatively longer, though the tufts on the fourth and fifth segments are not so large. About the middle of May (15th to 20th), the second spring molt occurs. The caterpillar is now about three fifths of an inch long, the yellow markings of the body being more apparent, and the brown tufts on the back less prominent. In this stage the upper hairs of the tubercles along the sides of the ab-

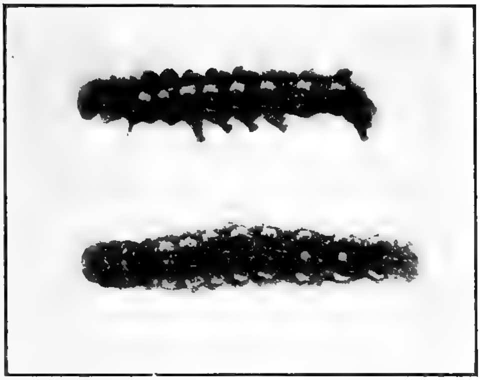


Fig. 11.—Full grown caterpillars of Brown-Tail Moth; enlarged 1½ times.

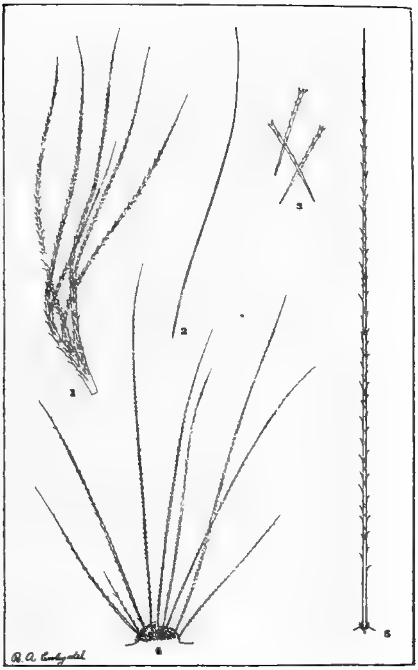


Fig. 12.—Various forms of hairs from Brown-Tail Moth caterpillar. (After Fernald and Kirkland.)

dominal segments are a distinct white color, forming a band of white dashes along either side of the caterpillar, which is so characteristic of it. The third molt occurs during the last week of May (May 28–30, 1905), this usually being the last molt before pupation, but sometimes, as described by Fernald and Kirkland, a fourth molt occurs, thus making five stages of the caterpillar in the spring. The caterpillars are now usually full grown (Fig. 11), and from an inch to an inch and a quarter long. The head is pale brown,

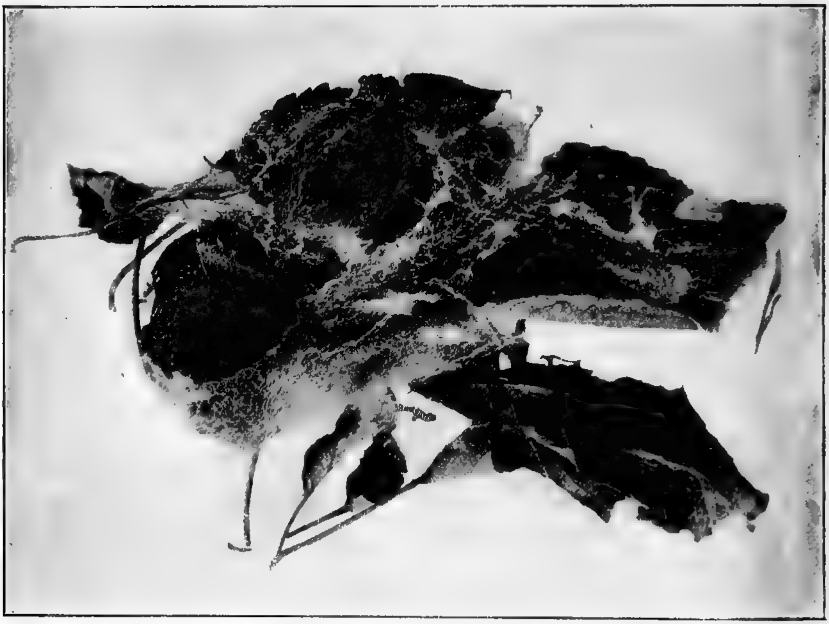


FIG. 13.—Several Brown-Tail Moth cocoons on leaves.

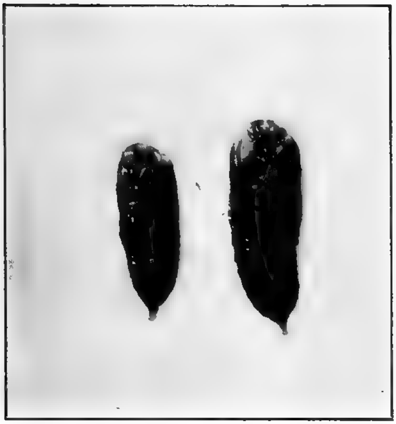


Fig. 14.—Pupæ, 1½ natural size. Male and female.

mottled with darker brown. The body is dark brown or black, well marked with patches of orange and covered with numerous tubercles bearing long barbed hairs. The tubercles along the back and sides of the abdomen are thickly covered with short brown hairs in addition to the longer ones, which give these tubercles a velvety appearance under a lens. It is these short hairs (Fig 12 at 3) which are the "nettling hairs." The white dashes along the sides of the abdomen are more prominent and enable the immediate identification of the caterpillar of the brown-tail moth from any other in New England. (See Fig. 11.)

Pupa.—During the second week in June the caterpillars spin up thin silken cocoons of white silk among the leaves, a number often spinning cocoons together, so as to form a considerable mass of web. The cocoon is so loose in structure that the cater-

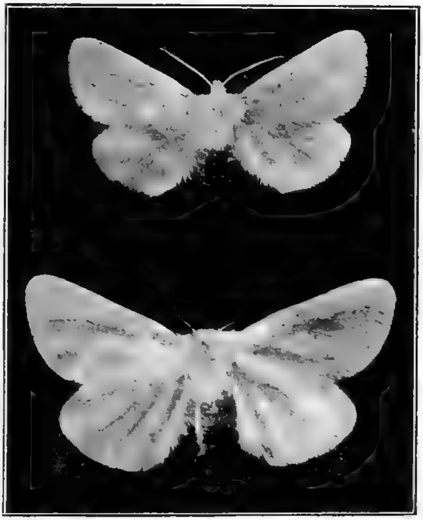


Fig. 15.—Brown-Tail Moths, natural size. Male above, female below.

pillar, or pupa, may be readily seen through it. Where abundant, they will make the cocoons (Fig. 12) under fences, beneath clapboards and in similar retreats. In these the caterpillars transform to pupæ about the middle or third week of June (June 15–18, 1905). The pupa, shown in figure 14, is slightly over half an inch long, of a dark brown color, with a conical spine armed with numerous small hooks at its tip. Smooth, yellowish-brown hairs are scattered over the abdomen and thorax, but none are on the antennæ, legs or wing-covers. The pupal stage lasts for about twenty days.

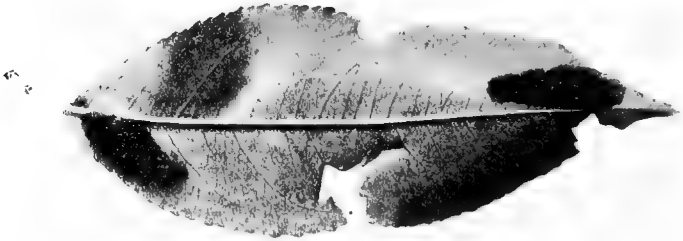


FIG. 16.—Eggs of the Brown-Tail Moth on leaf. (After Kirkland.) Reduced.

The Moth.—Most of the moths emerge during the second week of July (July 6 to 10, 1905, mostly emerging on 7th and 8th). They usually emerge late in the afternoon and are ready to fly that night. Both sexes are pure white, except the abdomen, which is dark brown. The wings of the males expand about one and one third and those of the females one and one half inches, as shown natural size in figure 15. The tip of the abdomen of the female forms a large tuft or brush of golden or dark brown hairs, to which is due the name of the insect. The moths are strong fliers and are readily attracted by lights.

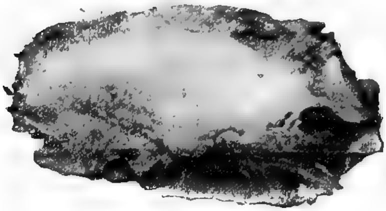
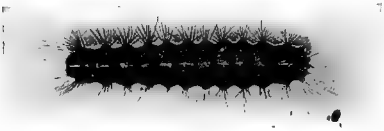
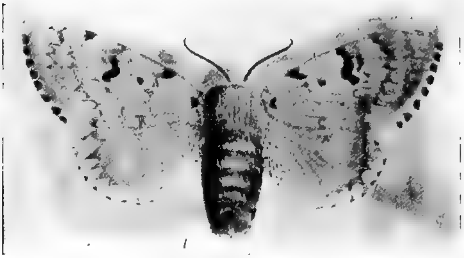
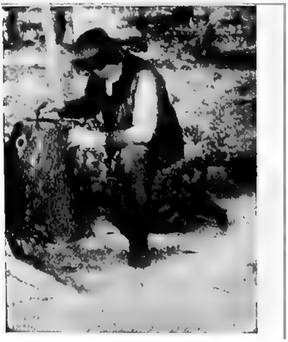
Eggs.—Egg-laying commences at once. The eggs (Fig. 16) are usually deposited on the under sides of the outer leaves of the tree, toward the tips of the limbs. An egg mass is about two thirds of an inch long by one fourth of an inch wide, contains from two to four hundred eggs, and is covered with dark brown hair from the tip of the abdomen of the female. The egg mass is elongate and is decidedly convex or ridged.

The eggs hatch in about three weeks, about the first of August. (Those at laboratory hatched July 31 to August 4, 1905. Were observed hatching at Rochester August 10, when almost all had hatched.) The young caterpillars feed upon the surfaces of the leaves, skeletonizing them, and when abundant causing the foliage to turn brown, as if blighted or scorched by fire (Fig. 17). At first they feed upon the leaf which bears the egg mass, but soon wander to others, returning at night to the original leaf. The little caterpillars are but a twelfth of an inch long when they first emerge, but in about five days they molt for the first time, after which they are about one fifth of an inch long. A week or so later a second molt occurs, though often this is within the winter web during the fall. Early in September the young caterpillars instinctively commence to weave the nest or web, their winter home. It is made of the leaves upon which they have been feeding, usually including the old egg mass at the tip of the twig. The form and shape of the web varies with the position and the materials available. Exit holes are left open so that the caterpillars may go in and out as long as the weather is propitious, but are usually closed during the winter.

Compared with the Gypsy Moth.—Inasmuch as the brown-tail and gypsy moths both were imported into the same region in Massachusetts and have spread simultaneously, they are very commonly confused. "That they were both transported across the Atlantic to the same locality by totally dissimilar agencies," as remarked by Mr. Kirkland[1], "must stand as one of the remarkable entomological events of the century just closed." And, it might be added, furnish the strongest evidence of the need of more rigid legislation against and inspection of all importations, either foreign or interstate, which may harbor insect pests. In view of this common confusion, a comparison of the stages and lives of these two insects was prepared for a recent bulletin (121) on the gypsy moth, and is here reprinted:

[1] Report Massachusetts Horticultural Society, 1902.

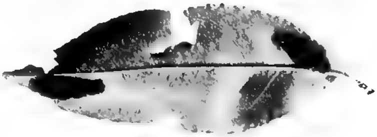
THE STAGES AND LIVES OF THE GYPSY MOTH

Stages.	Gypsy Moth.
Egg Cluster 	Usually on bark of tree; very rarely on leaf. Robust, 1½ to 2 inches long. Light yellow or creamy. From August to May.
Caterpillar. Full grown 	Dark grayish or sooty. Double row of five pairs of blue, followed by six pairs of red spots along back.
Moth. Female 	Wings spread 2¼ in. Dingy-white, lightly streaked and blotched with blackish. No brush of brown hairs at tip of abdomen. Does not fly, crawls.
Winter Passed	In egg stage—see above. Never as a caterpillar.
Irritation of Human Skin	Not caused by any stage.
Most Effective Means of Control. Soak eggs with creosote in fall, winter, or spring.	

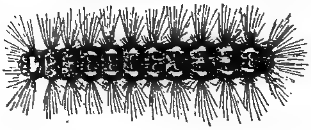
AND BROWN-TAIL MOTH CONTRASTED.

Brown-Tail Moth. — **Stages.**

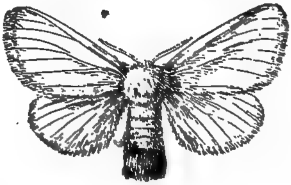
Always on under side of leaf...Egg Cluster.
Smaller and more slender.
Dark or golden brown.
July.



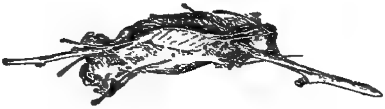
Bright tawny or orange......................Caterpillar.
A conspicuous row of pure white spots or dashes along each side of body.
Only two bright red spots on middle line at lower end of back.



Wings spread 1½ inches......................Moth, Female.
Pure snow white.
A conspicuous, sharply contrasted, thick tuft or patch of golden or brownish hairs at tip of abdomen.
A swift, strong flyer by night, and attracted to lights.



As small caterpillars in a silken web or nest on tips of twigs, from which they crawl out in spring. ....Winter Passed.



Irritation.

Hairs from caterpillars, which are often transferred to cocoons and moths, cause an annoying and painful irritation of the skin.

Most Effective Means of Control.

Cut off and burn webs in winter.

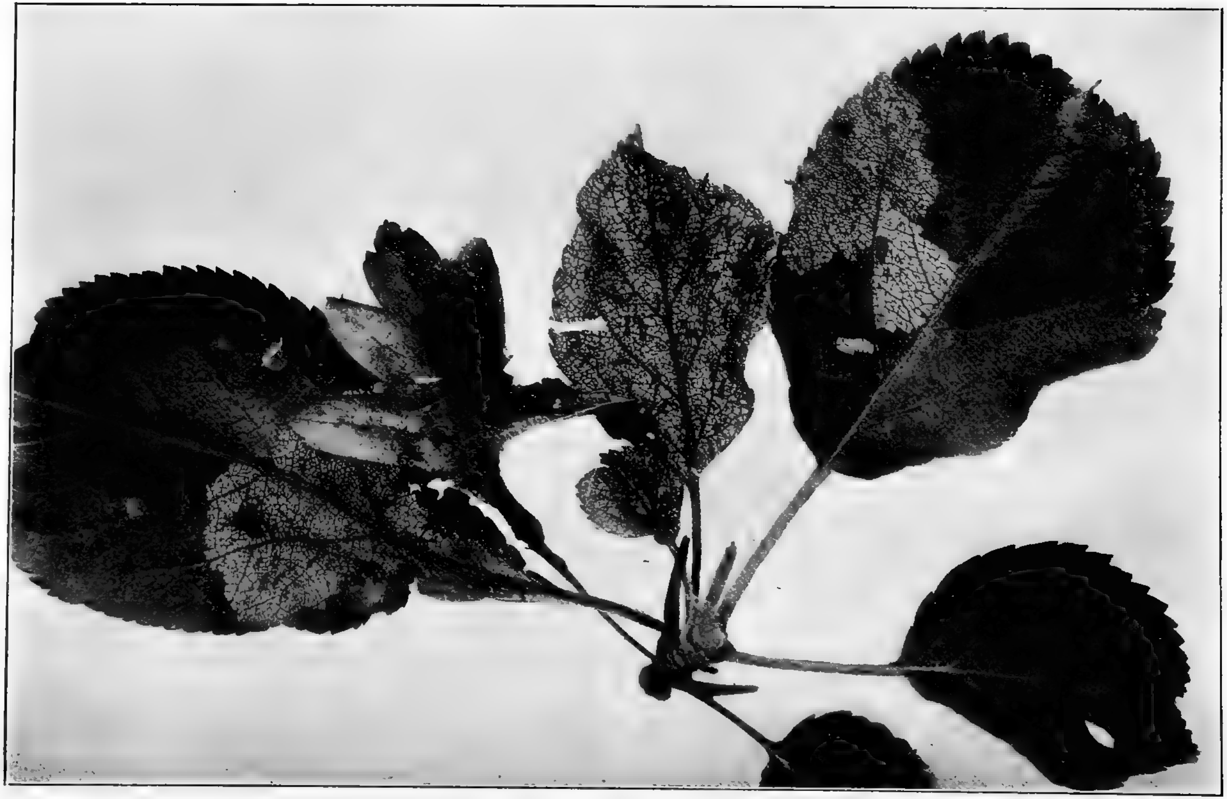


FIG. 17.—Leaves eaten by young caterpillars which have just emerged from egg mass at left, showing characteristic injury in fall.

MEANS OF DISTRIBUTION.

The principal spread takes place through the flight of the moths just after emergence. "These insects fly freely and have a habit of soaring upward above the tree tops and buildings. When the moths in their nocturnal flights have thus risen in the air, they are often drifted by the wind over long distances." (Fernald and Kirkland.) Thus the strong winds of mid-July, 1897, are known to have carried the moths far northward from the point of origin in Massachusetts and similar winds were undoubtedly responsible for the unusual spread northward and eastward in 1904.

It should be noted in this connection that as the moths are strongly attracted by lights they usually swarm around the electric lights in the center of a town and are always found first in towns and cities, which become centers from which the surrounding country becomes infested. This is a fortunate feature of their spread, for being thus naturally concentrated it is much easier to control the pest on the few town trees than if scattered over the country.

Due to this attraction by lights, the moths have often been spread by electric and railway cars, and possibly steamers. but particularly electrics, the moths flying into the cars and being carried some distance. It has been noticeable in a newly infested territory that the infestation runs along the electric car lines in advance of the main spread. Like those of the gypsy moth, the young caterpillars have the habit of dropping down from the trees by spinning a strand of silk by which they are suspended, so that they may be picked up by any passing vehicle or may crawl upon it and thus be carried. Undoubtedly this often occurs, but as the spread takes place so much more rapidly by the flight of the moths, it is of minor importance.

FOOD PLANTS AND INJURY.

The pear is the preferred food plant of the caterpillars and is usually first infested where available; the apple comes next and, owing to its abundance, is the tree upon which the webs are first most commonly found in a newly infested section. All of the fruit trees and of the shade trees, elm, oak and maple, are freely attacked, in fact, almost all fruit, shade and forest trees, except the pines, spruces and other conifers are attacked in a badly infested district. Injury to woodlands and forests does not seem to be as serious as that inflicted by the gypsy moth, though often the defoliation is sufficient to cause large tracts to appear brown and seared. As yet, woodlands have not been infested sufficiently for a time long enough to definitely determine just how serious the constant total or partial defoliation by the brown-tail caterpillars will be. It is well known, however, that any deciduous tree wholly defoliated for three or four years is usually killed, and that the wood growth is seriously checked by partial defoliation, so that there is a distinct loss in the timber value.

As the pest concentrates in towns, the shade and fruit trees suffer most and, unless the winter webs are removed, being defoliated year after year, become weakened and soon die. As when defoliated by cankerworms, tent-caterpillars or other caterpillars, fruit trees stripped of their foliage can hardly yield a crop of fruit and the control of the pest upon them is therefore imperative.

DANGER TO HEALTH.[1]

One of the most serious effects of the presence of the brown-tail moth in a community is that of the peculiar skin disease it may produce. Some of the hairs of the full-grown caterpillars are furnished with minute barbs. When the caterpillars molt these barbed hairs are shed with the skin and as the skins become dry and are blown about by the wind the hairs may be quite generally disseminated. When the hairs alight upon the human skin they cause an irritation, which upon rubbing may develop into inflammation. In New Hampshire this phase of the insect's presence has already become evident. At Portsmouth a clothes-reel was near a tree infested by the caterpillars. The family were greatly troubled through the summer by extraordinary irritations of the skin, for which they were unable to account, but which were doubtless due to caterpillar hairs blown from the pear tree to the clothes upon the reel. In the same city a gentleman, in removing a caterpillar which had landed upon his neck, scattered some of the hairs, which produced an eruption similar to but considerably worse than that produced by poison ivy.

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[1] Largely reprinted from Bulletin 107 by C. M. Weed.

In Massachusetts, where the infestation has been longer known, this danger has become very generally recognized. The following experiences recorded in the report on the brown-tail moth, by Messrs. Fernald and Kirkland, are simply examples of many others which have been reported to the authorities:

A lady in Somerville wrote: "We were shockingly poisoned by the caterpillars of the brown-tail moth. They troubled us all summer. Every member of my family was poisoned. At first we did not know what they were. My little boy could not go near the insects without getting poisoned,—every time he went to pick cherries he would come down from the tree badly poisoned. If my baby went near where they were, his face would break out into a rash. I was so dreadfully poisoned that I thought I had some frightful disease. My hands, face and arms were broken out with this rash. Most of the caterpillars came from a neighbor's place. They came over the fence into the house and even into the closets. They would get on the clothes hung on the line, and when these were worn they poisoned us."

A Somerville physician wrote: "The first we saw of these moths was in 1897. The first cases of poisoning I saw were on Spring Hill Road and Park Street. I saw a number of cases and they were all about the same, except that they varied in point of severity. Some of the cases were very obstinate, and did not respond well to treatment. The same symptoms developed in nearly all cases. The trouble began with an intense irritation, then an eruption appeared, resembling eczema, with a sort of watery blister on the top. There was intense irritation all over the body, on the head, arms and limbs. I saw numbers and numbers of cases of this poisoning; I should say nearly a hundred cases in all came under my observation. The irritation seemed to remain and was much worse than that caused by poison oak or poison ivy, and was not so easily gotten rid of. I treated most cases with some cooling application. Some cases were decidedly obstinate, but no case was serious enough to menace the life of the patient.''

Investigations by Massachusetts authorities of this consequence of the presence of the brown-tail moth showed that it was due to the mechanical irritation of the barbs of certain short hairs on the body of the caterpillar; these hairs are called the nettling-hairs. ''These nettling-hairs are very small, only about one two hundred and fiftieth of an inch in length, very sharp at one end, and with two or three barbs at the other end and many along the sides. These barbs are so arranged that when these nettling-hairs fall upon the skin any movement will cause them to work into the flesh. The nettling of the skin may be caused by contact with the caterpillars in either of the last two molts, the cocoons, and to some extent with the moths, but contact is not necessary, as these fine nettling spines may fall or be blown by the wind.''

The true nettling hairs are the short brown hairs giving the tubercles of the back and sides of the abdomen a brown velvety appearance, shown in figure 12 at 3, and do not appear until the last two stages of the caterpillar's growth. Nettling may be produced, however, as we have learned from experience, by the younger stages, even those in the webs, where they are freely handled by one with a tender skin. No inconvenience would occur to anyone, however, from handling the unopened webs, and rarely will the young caterpillars be annoying.

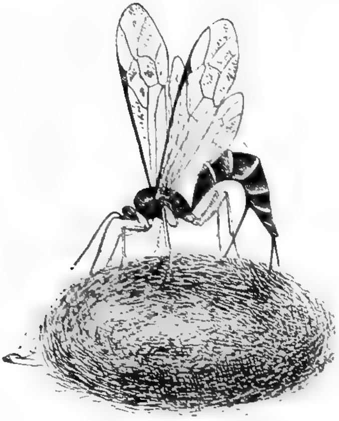


FIG. 18.—Pimpla fly on cocoon of tent caterpillar. One of the native parasites of the Brown-Tail Moth. Twice natural size. (After Weed.)

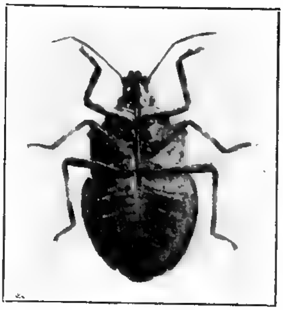


FIG. 19.—A predaceous bug (*Brachymena 4-pustulata*), such as feed upon the Brown-Tail caterpillars, seen from below, and showing the long, sharp beak between the legs, upon which the caterpillars are impaled.

NATURAL ENEMIES.

A number of parasitic insects which commonly live upon our native caterpillars attack the larvæ and have been bred from the pupæ (Fig. 18) of the brown-tail moth. Predaceous bugs (Fig. 19) also appear in numbers on infested trees and devour large numbers. Toads and bats eat the moths as they fly to electric lights. The worst enemy of the moths, however, is the English sparrow, which attacks them eagerly and consumes large numbers, as well as killing many not eaten. All of the common birds which feed upon our native hairy caterpillars feed upon those of the brown-tail, particularly the Baltimore oriole, cuckoos and yellow-throated vireo. When the moths commence to emerge they join with the sparrows in the slaughter and between them large numbers are destroyed. But as yet the native enemies have not shown ability to materially check the increase of the pest.

It is well known that in Europe the insect seems to be largely controlled by its natural enemies, so that serious outbreaks occur but once in a number of years in any one locality, in the same manner as do outbreaks of our native insects, such as the forest tent caterpillar or white-marked tussock moth, which are controlled by native parasites. A determined effort is, therefore, now being made by the Massachusetts superintendent, in coöperation with the Bureau of Entomology of the United States Department of Agriculture, in importing those parasites and predaceous insects which prey upon the brown-tail and gypsy moths in Europe. Already large numbers have been imported from all parts of Europe and are being carefully reared in strict confinement at Saugus, Mass. It is the hope of everyone that these importations may result, within a few years, in such an increase of these enemies that they will be able to control these pests. It is the belief of the writer that ultimately either imported or native enemies will control them, as they do our native insects; but Nature works slowly, and whether such a condition will arise in five, ten or one hundred years, it is impossible to predict, as we have no experience with imported pests of a nature sufficiently similar to furnish us any precedent for comparison. Obviously, therefore, it will be folly to place any dependence upon these natural enemies until their value and ability to even partially control the brown-tail moth is clearly established.

REMEDIES.

Destruction of the Winter Webs.—Of all the means for controlling the brown-tail moth, the destruction of the winter webs or nests is by far the most important, the most practical, economical and efficient. The webs are conspicuous on the tips of the limbs from October to April and usually may be readily removed by pole shears or long-handled pruners. All webs should be collected and burned in a stove, as they do not burn readily and if burned in an open fire out of doors some may be merely scorched, and if the nests be allowed to lie on the ground or in a brush heap the young caterpillars will emerge in spring and usually find plenty of food. When the snow is on the ground the nests may be more readily found where they drop. On large trees with numerous nests it is well to have one man below the tree to point out the nests to two or three men doing the pruning, thus saving time and ensuring thorough work. Long ladders and climbing irons will occasionally be necessary for high trees and will be found useful by those making a business of collecting the webs. All webs should be removed by April 1.

The question is often asked, "Will it pay me to clean the webs from my own trees if my neighbor does not?" A glance at figure 20 will answer this better than argument. From the habits of the pest it is apparent that but little spread takes place except by the winged moths in late summer. If the caterpillars are so abundant as to spread from neighboring property they may be prevented by sticky bands on the uninfested trees as described below.

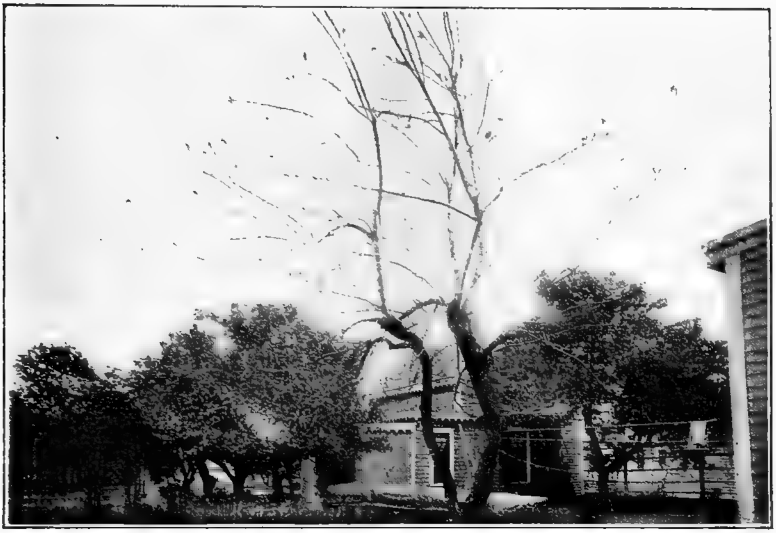


FIG. 20.—Pear tree defoliated by the caterpillars of the Brown-Tail Moth. The webs on the trees in the background were destroyed the previous winter. Photograph taken at Vine Street, Somerville, Mass., May 27, 1897. (After Fernald and Kirkland.)

Spraying.—While the caterpillars are young they may be effectively destroyed by spraying with arsenate of lead. The brown-tail caterpillars seem to be much more susceptible to the poison than those of the gypsy moth. Experiments made by us during the past season in the laboratory indicate that if sprayed while the caterpillars are young early in May that arsenate of lead at the rate of three pounds per barrel of water should be sufficient, but if delayed until late in May or June 1, when they are nearly full grown, five pounds per barrel should be used. More elaborate field experiments concerning the strength necessary will be conducted this year.

After the eggs have hatched in August the trees may also often be sprayed to advantage so as to prevent the work of the young caterpillars and the consequent checking of the fall growth of the tree, except in the case of trees in fruit.

Spraying or sprinkling with kerosene emulsion or strong soap solution will often destroy the caterpillars when they swarm on fences and walks.

Banding.—Uninfested trees may often be protected by applying a band of some sticky substance over which the caterpillars are unable to cross. This will *not* be effective (1) if the branches of the trees interlock with those of an infested tree; (2) if the trees stand so close together that the small caterpillars can pass from one to the other while suspended on their fine threads; (3) if the band either hardens or becomes covered with dust so that it does not remain sticky; and (4) if the caterpillars are allowed to become so numerous beneath the band that they form a bridge over it with their threads and dead bodies. The bands should therefore be frequently inspected and the caterpillars below them removed or destroyed. If not destroyed they will often leave the trees for shrubbery, where it is more difficult to cope with them, and will transform to moths. "Insect lime, raupenleim, tanglefoot, bodlime, printer's ink, or even axle grease are among the materials most used for banding. All may be dangerous to the tree and should be removed after the caterpillar season has passed." (Kirkland.) Possibly the most satisfactory and safest substance is printer's ink applied as a band on heavy building paper, beneath which is placed a band of cotton next to the bark of the tree to prevent the ink from injuring the tree and the ascent of the caterpillars in the crevices of the bark beneath the paper.

This banding will not, however, prevent reinfestation by the winged moths, which fly to them and deposit their egg clusters in July, so that it is not as efficient as in the case of the gypsy moth, which does not spread by flight, and which makes apparent the necessity of destroying the insect in its immature stages as far as possible, so that the winged moths may not spread, if its numbers are to be reduced from year to year.

Destroying Pupæ.—Late in June and early July the cocoons containing the pupæ may be gathered, though it is likely to be attended with severe inflammation of the skin from the nettling hairs if precautions are not taken. Such cocoons or pupæ should be placed in a barrel or box covered with mosquito screening so that the moths are confined but any parasites which develop may escape through the screen.

Destroying the Moths.—Often the electric light and telegraph poles near lights are covered with the white-winged moths, in which case they may be largely destroyed by washing down with a stiff jet of water from the hydrant hose. A spray of pure kerosene or kerosene emulsion may also be found desirable under some circumstances for destroying the moths.

NECESSITY OF THE CONTROL OF THE BROWN-TAIL MOTH.

In the southeastern corner of the state, where the brown-tail moth has now become abundant, everyone is impressed with the importance of doing everything possible to suppress or control it, as are those persons who have been unfortunate enough to have visited in the infested district in Massachusetts during the caterpillar season. In general the New Hampshire public seems alive to the necessity of the control of the pest. As a result the last Legislature enacted a law (Senate bill 22) authorizing "the several towns and cities of the state" "to appropriate and expend money to limit and if possible exterminate the ravages of the brown-tail moth and other insect pests." In 1905 most of the towns of southeastern New Hampshire appropriated money for the control of the pest. Some placed the funds in charge of the tree warden while other offered a bounty for each winter nest collected. The bounty method is fairly effective where the nests are few and has the value of arousing general public interest and coöperation in the work. Where the nests become more numerous, better results may be more economically secured by the town or city appropriating funds to some official who may hire reliable men, who will soon become expert at the work, and will see that all trees are thoroughly cleaned. All trees along the public highways and in parks should be cleaned by them, and their services should be placed at the disposal of property owners who would pay the actual wages of those employed by them, as far as would not interfere with the town work. At the present time the authority which the town or city has over trees along the public highways seems to be more or less poorly defined and in connection with the work against the brown-tail and gypsy moths it is of the utmost importance that legislation be enacted which will, if possible, clearly define the rights and duties of the towns and municipalities in this regard.

Attorney-General Eastman has kindly informed the State Board of Agriculture that "the highways agents and the selectmen of towns, one or both, may remove the webs of the brown-tail moth from trees within the limits of the public highways." He further states that neither selectmen nor city councils probably have power to enact ordinances compelling property owners to remove the webs. This being the case, it is highly desirable that state legislation be enacted, which might well be patterned after the Massachusetts law in this respect, requiring all property owners to remove the webs and requiring town officials to see that this is properly done, appropriating a sufficient sum, so that after a reasonable amount has been expended by property owners and towns the state will stand a share of the expense of such work. Otherwise one town may carefully remove the webs each year and yet will make no headway against the pest, owing to the neglect of a neighboring town.

Appropriations for this work have been made by many towns in town meeting only sufficient for the work of that spring. It were much better if a sufficient sum were voted to cover the work of that spring and the following winter, stating that only so much could be used prior to November of that year. This would make work possible during the good weather of early winter.

IDENTIFICATION OF SPECIMENS.

The writer will be glad to identify any specimens thought to be brown-tail moth webs or caterpillars. He will also be materially assisted in determining the spread and abundance of the pest if (1) all information possible be sent him concerning its occurrence outside of the area indicated on the map, figure 1, and (2) if local officials having charge of removing webs will keep account of the number of webs removed from street trees and forward the record to him each year, as in this way a comparison of the abundance in different parts of the state may be made.

For further accounts of the brown-tail moth see,—Fernald and Kirkland, "The Brown-Tail Moth," Massachusetts State Board of Agriculture, pages 73, plates 14, 1903, and Kirkland, Bulletin 1, Office of Superintendent for Suppression of Gypsy and Brown–Tail Moths, 1905.

Bulletin 121 **December, 1905**

NEW HAMPSHIRE COLLEGE

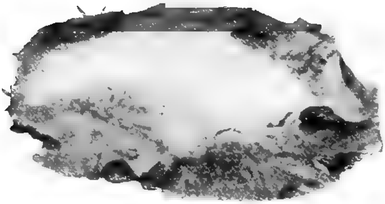
Agricultural Experiment Station

IN COÖPERATION WITH THE

State Board of Agriculture

THE GYPSY MOTH

IN NEW HAMPSHIRE



EGG MASS OF THE GYPSY MOTH ON BARK
The vital stage in which to destroy the pest

By E. DWIGHT SANDERSON
Entomologist to the Station and State Nursery Inspector

NEW HAMPSHIRE COLLEGE
OF
AGRICULTURE AND THE MECHANIC ARTS
DURHAM

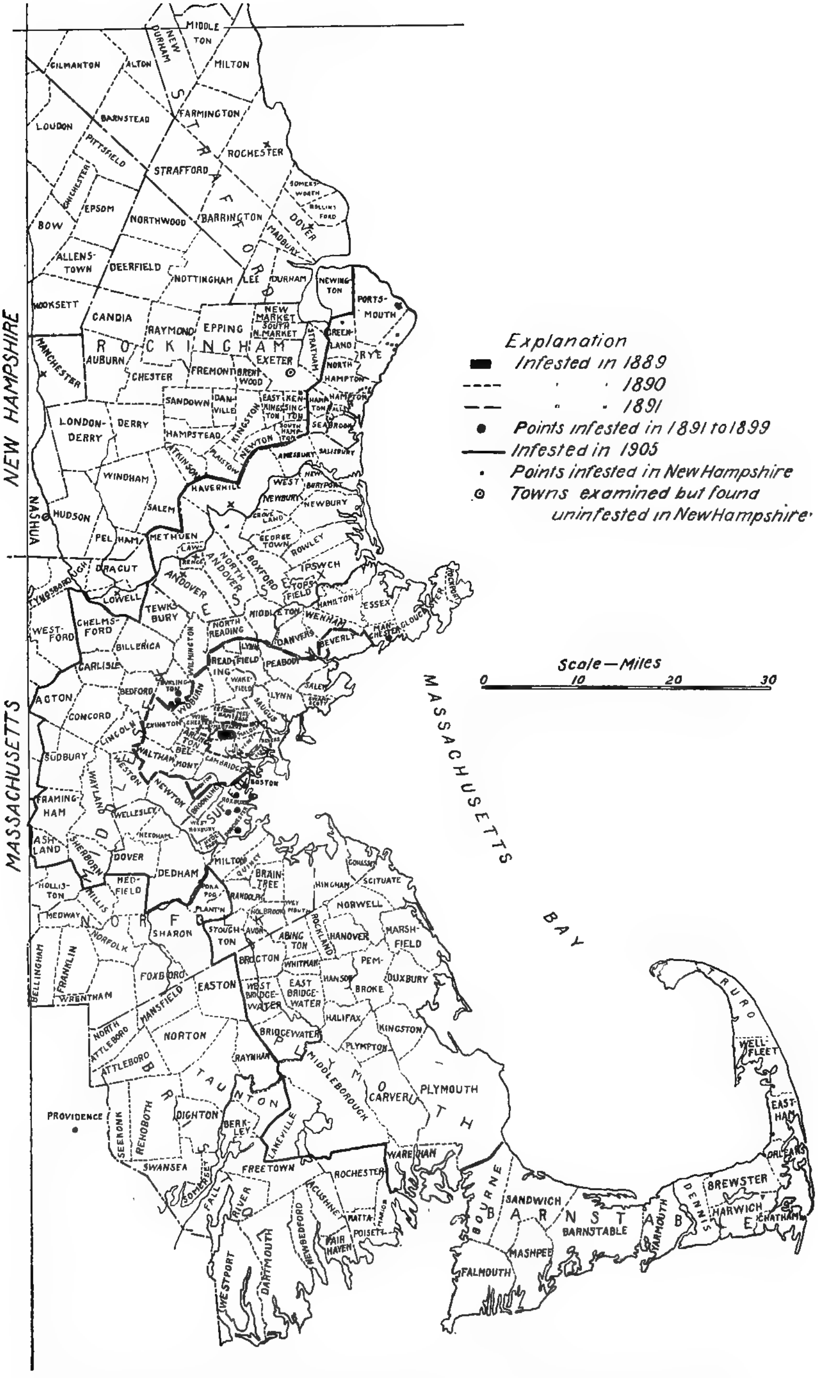


FIG. 1.—Map showing gradual spread and present distribution of the Gypsy Moth.

THE GYPSY MOTH.

HISTORY.

The gypsy moth has been known as a serious insect pest in Europe from the time of the earliest naturalists, the first authentic record being in 1662. It extends throughout the continent of Europe, over much of Asia and into Northern Africa, but is chiefly injurious in Central and Eastern Europe. There it frequently does serious injury by defoliating large areas of forest and more frequently fruit and shade trees, but its ravages cease in two or three seasons, not to occur again for several years, like those of many of our native insects, such as the Forest Tent Caterpillar and Tussock moth. In 1868 the insect was brought to this country by Prof. Leopold Trouvelot at Medford, Mass., in his experiments in silk producing. Escaping from him into the neighboring woodland, the insect increased gradually for several years before noticed, but in 1890 had become such a serious pest throughout this and neighboring towns that the State of Massachusetts commenced the arduous task of its extermination. In 1890 the insect had invaded some twenty towns, from Cambridge on the south to Lexington on the west, and Reading and Beverly on the north, as shown in Figure 1. This work was ably carried on by the Gypsy Moth Commission and the Massachusetts Board of Agriculture, who annually employed a small army of men in the fight, and who expended up to 1900 approximately a million and a quarter of dollars. As a result, so few of the moths could be found in 1899 and so little damage was caused by the insect, that the Legislature of 1900, probably not realizing the necessity of continuing control measures, stopped the work. Had a small annual appropriation been made and continued at this time, the future spread would undoubtedly have been prevented and the control of the insect become more and more effectual, though utter extermination might never have been possible. However, in 1898, "in seven of the formerly infested towns no gypsy moths were found. In five others but one to three small spots were found infested, and in these no eggs were found in the fall inspection; in the other outer towns comparatively few moths were found." (Forbush.) In 1898 the insect had spread to but three towns outside those infested in 1890, when the work began. The possibility of the practical control of the pest was, therefore, thoroughly established.

The Present Condition.—Since 1900 the only effort toward control has been by local towns and private parties, with but partial success, owing to the lack of concerted action. In 1904 the moth had increased so enormously that it became evident that state aid was again necessary for its control and the Massachusetts Legislature of 1905 made an appropriation of $150,000 per annum for aiding the towns in the work. Under this act a state superintendent, appointed by the governor, Mr. A. H. Kirkland, formerly assistant-entomologist to the Gypsy Moth Committee, has general oversight of all the work. During the past season inspections made by his assistants show that the moth has spread in Massachusetts to some one hundred and twenty towns, extending north to the New Hampshire line, west to Chelmsford, Concord and Sherborn, and south and east to Plymouth, extending over four times the area previously infested. At the present time, in addition to the state appropriation, private citizens of Massachusetts are spending about $125,000 to protect their property and the towns and cities are spending some $75,000 to protect their street trees. Notwithstanding this, during the last few years while no state work was being done, acres of valuable pine and soft-wood timber, and hundreds of stately shade trees have been killed by the caterpillers, while hundreds of acres of woodland are now so badly infested that it is questionable whether it will be profitable to attempt the control of the insect upon them.

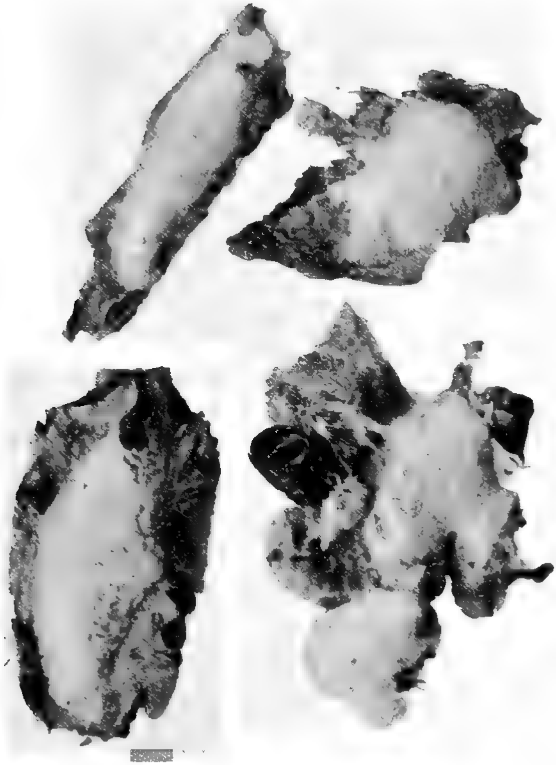


FIG. 2.—Egg masses of Gypsy Moth on bits of bark cut from tree trunk, natural size.

LIFE HISTORY.

Like all insects of its class, the gypsy moth passes through four different stages during its life history.

The Egg.—(Figure 2.) The eggs are laid in July and August, in a mass of 400 to 500, covered with yellowish hairs from the body of the female. The individual mass is of an irregular oval shape, one and one-half by three-fourths inches, as shown natural size in Figure 2, and is usually deposited on the bark of trees, but where abundant on fences, stones, buildings, etc.

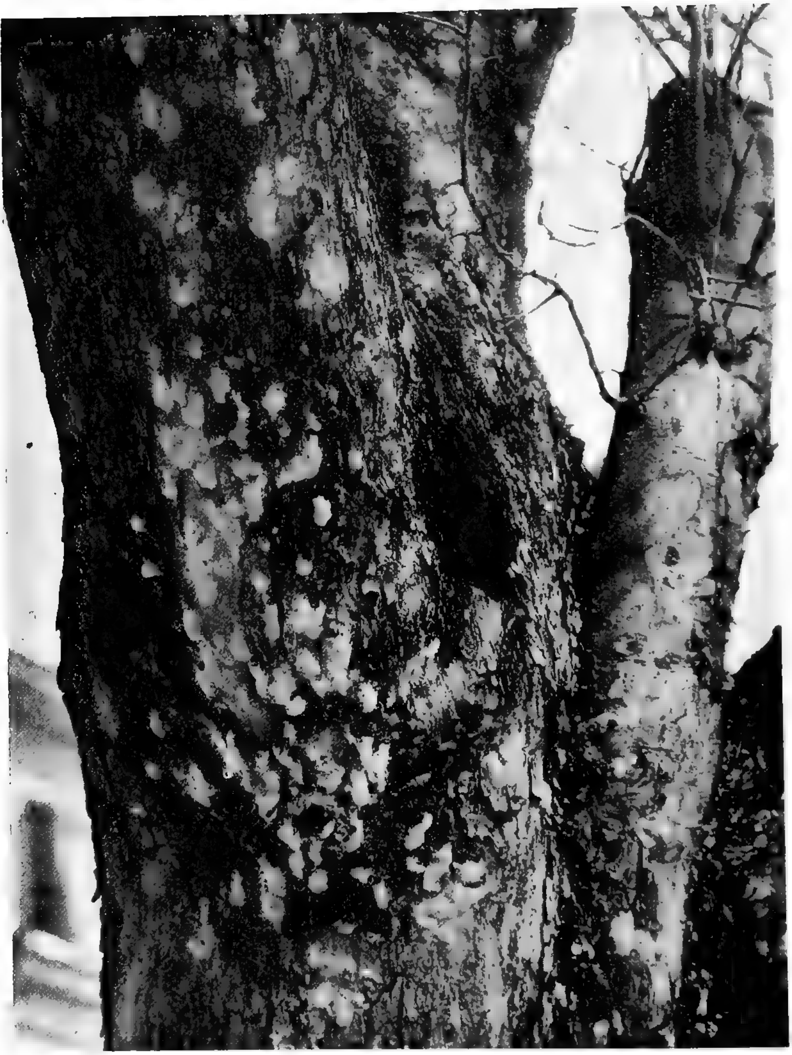


FIG. 3.—Egg masses on neglected apple tree, Arlington, Mass., March, 1905.

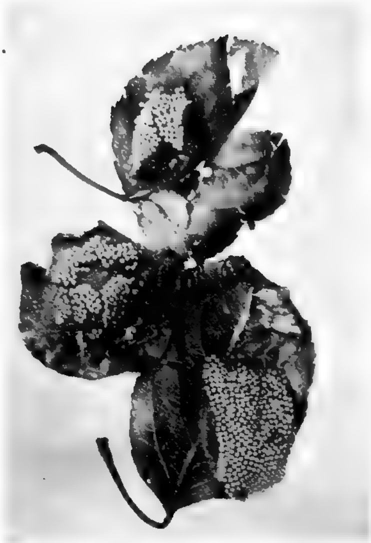


FIG. 4.—Eggs of Rusty Tussock Moth. (*Notolophus antiqua* Linn.)

The eggs of two species of our common tussock moths might be readily mistaken for those of the gypsy by one unfamiliar with the latter. The eggs of the Rusty Tussock moth (*Notolophus antiqua* Linn.), which is the more common species, except in Southern New Hampshire, are usually laid on the leaves which remain attached to the tree and are laid in but a single layer with no protecting cover over them, so that each egg is distinguishable, as seen in Figure 4. The eggs of the common White-Marked Tussock moth (*Hemerocampa leucostigma* S. & A.), which is common in Southern New Hampshire and southward, often doing serious damage to shade trees in the cities of the Middle States, are covered with a white frothy substance and laid in a compact mass upon the trunk or limbs of a tree, and are not unlike the egg masses of the gypsy moth. The mass of the tussock moth is pure white, while that of the gypsy is yellowish or dark creamy, from the hairs or scales from the body of the female which cover it, which are entirely absent from the eggs of the tussock moth. The eggs of the tussock moth (see Figure 5, which illustrates the well-known tussock caterpillar), are usually laid on the cocoon from which the female emerged, while those of the gypsy moth are laid directly on the bark of the tree.

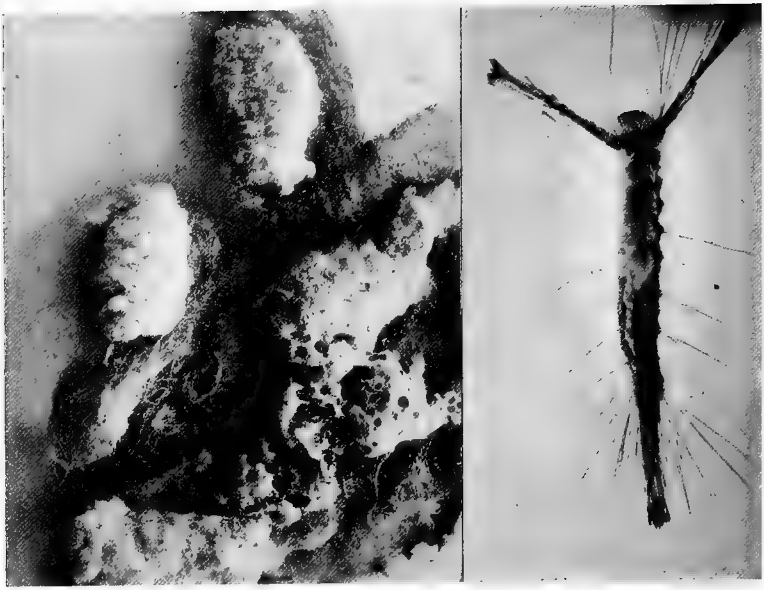


FIG. 5.—Eggs of White-Marked Tussock Moth on cocoons of females, and full-grown caterpillar, natural size.

The Caterpillar or Larva.—(Figure 6.) "The eggs hatch about May 1 and each mass or 'cluster' yields a swarm of young caterpillars, the bulk of which become full grown by midsummer. Gypsy moth caterpillars of any age are decidedly hairy. The mature caterpillar has a dusky or sooty-colored body. Along the back, counting from the head, which is marked with yellow, is a double row of five pairs of blue spots, followed by a double row of six pairs of red spots. This double row of spots may almost invariably be seen very distinctly on the back of a caterpillar which has attained a length of one inch and a half or more. No other New England larva has this double row of blue and red spots along its back. The mature gypsy moth caterpillar not infrequently attains a length of three inches." * The

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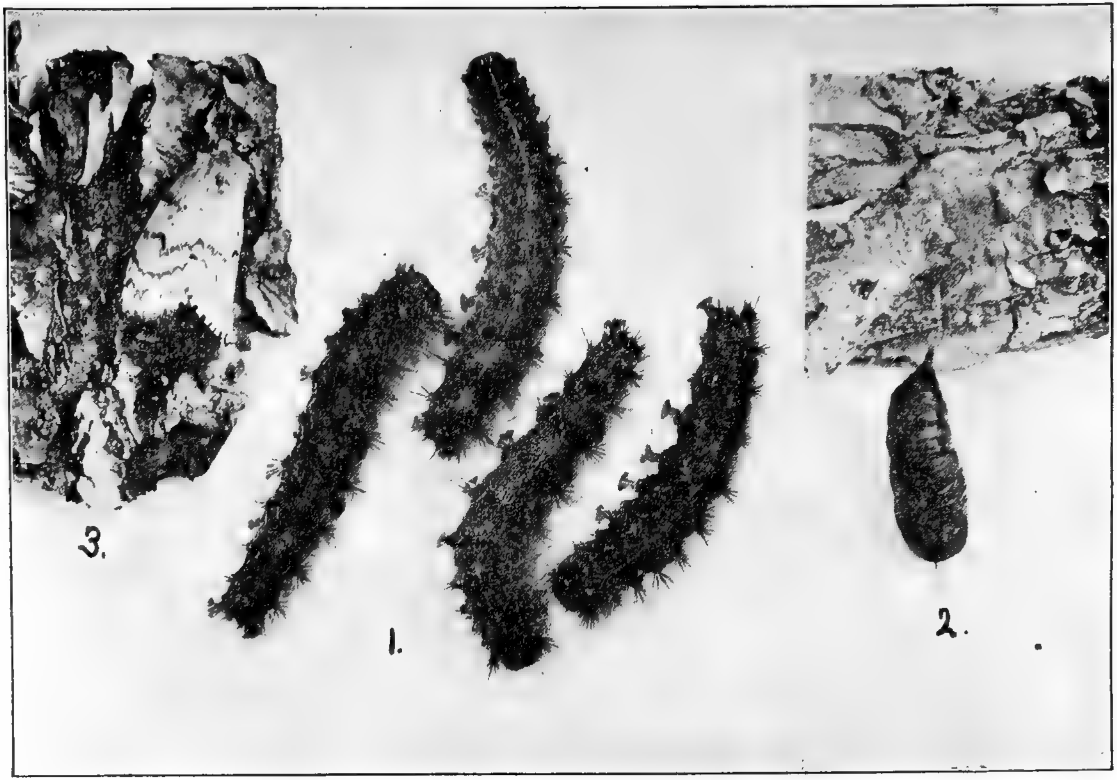
*From Bulletin 1, Office of Superintendent, for Suppressing the Gypsy and Brown-tail Moths, of Massachusetts, by A. H. Kirkland, from which are all other quotations, unless otherwise indicated, and to which we are indebted for much of the present article not directly quoted.



THE GYPSY MOTH.

FIG. 7.—Female laying eggs. FIG. 6.—Full-grown caterpillars. Pupa.
All life size (after Kirkland)

caterpillars become full grown during July, mostly about the first. Injury done by the pest is, therefore, largely confined to the months of May and June, being most serious as the caterpillars become grown.

The Pupa.—"When fully grown, usually in July, the caterpillar spins a few threads of silk as a supporting framework, casts its skin and changes into a pupa, or, as it is sometimes called, a chrysalis. The pupa is dark reddish or chocolate in color and very thinly sprinkled with light reddish hairs. Unfortunately, it resembles the pupæ of certain other moths found in Massachusetts (and New England), and cannot, unless by experts, be identified at a glance. The thinly sprinkled, light reddish hairs are, however, characteristic." The pupa stage lasts from 10 days to two weeks, during which time the insect is comparatively dormant, while the wonderful changes take place by which the tissues of the worm-like caterpillar are so transformed that from the apparently lifeless pupa, the winged, adult moth emerges.

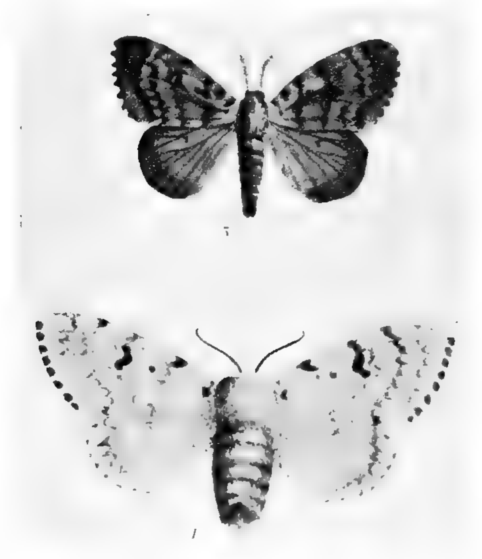


FIG. 8.—Male and Female Gypsy Moths. Natural size. (After Forbush and Fernald.)

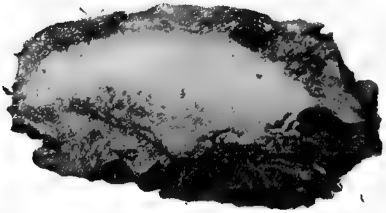
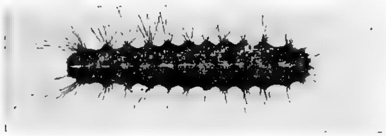
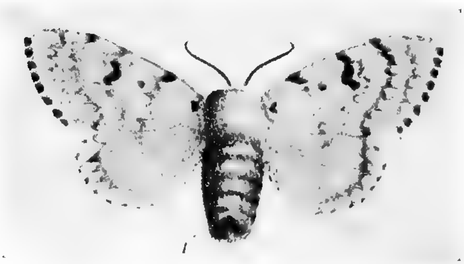
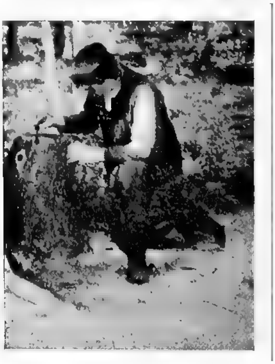
The Moth.—(Figure 8.) "From July 15 to August 15 the winged moths emerge from the pupæ, the date varying according to the season and the time of pupation. The male moth is brownish yellow, varying to greenish-brown in color, has a slender body and expands about one and one-half inches. It flies by day with a peculiar zig-zag flight.

"The female moth is nearly white, with numerous small black markings, heavy-bodied and sluggish, and expands about two inches. The female does not fly, otherwise the spread of the gypsy moth would be most rapid. After mating the moths live but a short time. The female dies after depositing her egg mass (Figure 7.) The winged moths take no food. All damage to foliage is caused by the caterpillars."

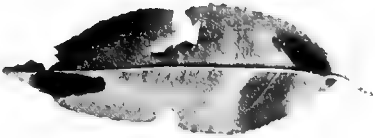
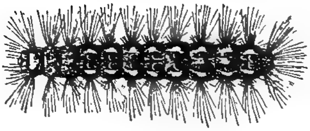
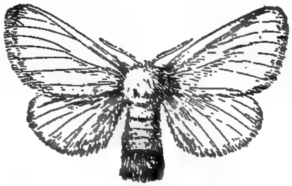
The eggs remain over winter on the trees, as already described. Thus, there is but one brood or generation of the gypsy moth in a year, the different stages of which in their relation to each other are shown graphically in Figure 9.

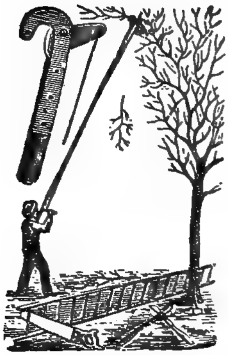
In view of the fact that the brown-tail moth has also recently been introduced into the state and that it is frequently confused with the gypsy moth, the following table may be of service in sharply distinguishing the two species, which are totally different in habits and require different methods of control:

THE STAGES AND LIVES OF THE GYPSY MOTH

STAGES.	GYPSY MOTH.
EGG CLUSTER 	Usually on bark of tree; very rarely on leaf. Robust, 1½ to 2 inches long. Light yellow or creamy. From August to May.
CATERPILLAR. Full grown 	Dark grayish or sooty. Double row of five pairs of blue, followed by six pairs of red spots along back.
MOTH. Female 	Wings spread 2¼ in. Dingy-white, lightly streaked and blotched with blackish. No brush of brown hairs at tip of abdomen. Does not fly, crawls.
WINTER PASSED	In egg stage—see above. Never as a caterpillar.
IRRITATION OF HUMAN SKIN	Not caused by any stage.
MOST EFFECTIVE MEANS OF CONTROL. Soak eggs with creosote in fall, winter, or spring.	

AND BROWN-TAIL MOTH CONTRASTED.

Brown-Tail Moth.	Stages.
Always on under side of leaf. Smaller and more slender. Dark or golden brown. July.	Egg Cluster. 
Bright tawny or orange. A conspicuous row of pure white spots or dashes along each side of body. Only two bright red spots on middle line at lower end of back.	Caterpillar. 
Wings spread 1½ inches..... Pure snow white.	Moth, Female.
A conspicuous, sharply contrasted, thick tuft or patch of golden or brownish hairs at tip of abdomen. A swift, strong flyer, by night, and attracted to lights.	
As small caterpillars in a silken web or nest on tips of twigs, from which they crawl out in spring.	Winter Passed.



Irritation.

Hairs from caterpillars, which are often transferred to cocoons and moths, cause an annoying and painful irritation of the skin.

Most Effective Means of Control.

Cut off and burn webs in winter.

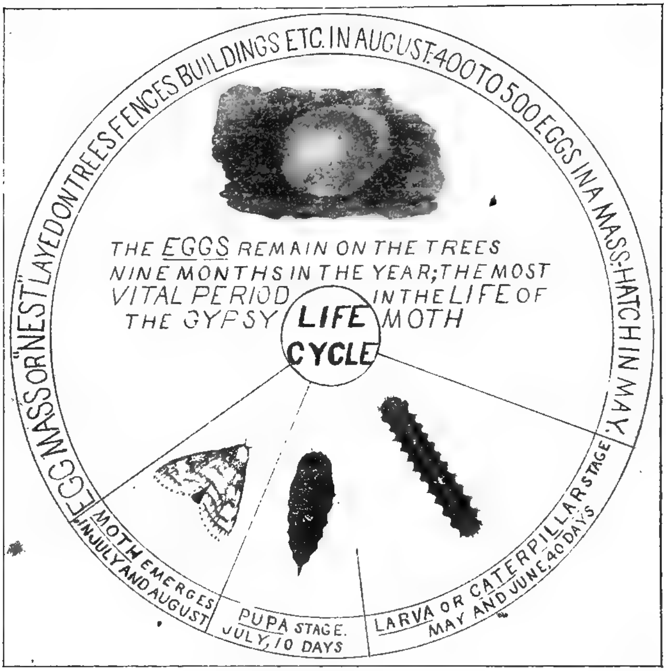

EGG MASS OR "NEST" LAYED ON TREES FENCES BUILDINGS ETC. IN AUGUST. 400 TO 500 EGGS IN A MASS. HATCH IN MAY.
THE EGGS REMAIN ON THE TREES NINE MONTHS IN THE YEAR; THE MOST VITAL PERIOD IN THE LIFE OF THE GYPSY MOTH
LIFE CYCLE
LARVA OR CATERPILLAR STAGE MAY AND JUNE 40 DAYS
PUPA STAGE. JULY, 10 DAYS
MOTH EMERGES IN JULY AND AUGUST

FIG. 9.—The Life Cycle of the Gypsy Moth. (Figures after Forbush and Fernald.)

MEANS OF DISTRIBUTION.

"The gypsy moth spreads chiefly during the caterpillar stage. While the caterpillars do not crawl very far from where they hatch, except when there is a scarcity of food, they have the habit, when small and young, of spinning down on their silken threads from trees (as do the canker worm caterpillars in orchards), and, falling on vehicles, are then carried from place to place. Electric cars, pleasure and business vehicles, bicycles and automobiles are common means of thus transporting the gypsy moth.

"The special attention of all those upon whom gypsy moth suppression devolves is, therefore, directed to the necessity of keeping travelled highways free from the insect.

The caterpillars often crawl upon vehicles standing in an infested spot and by this means, also, are carried from one place to another.''

The writer has no doubt that practically all of the infestations of gypsy moth in New Hampshire have been introduced by automobiles, as they are practically the only vehicles, other than railroad cars, coming directly from the badly infested region of Massachusetts, and the infestations are found along the main roads and not near the railroads. Indeed, one case has come to our attention in which the owner of an automobile coming from Malden, Mass., removed a half dozen caterpillars from his machine upon arriving at Greenland, N. H., which were believed to be, and doubtless were, those of the gypsy moth.

''The egg clusters of the gypsy moth may also be transported on any of the numerous objects on which they are laid. Freight cars that have stood near the infested foliage for a period long enough for the laying of gypsy moth eggs upon them may even transport the pest.'' It is surprising, however, that as yet no instances have become known in which freight cars have carried the eggs, so that a colony of the moth has arisen at any distance from the badly infested regions, though certainly abundant opportunity must have arisen in past years.

DISTRIBUTION IN NEW HAMPSHIRE.

Realizing the probability of the spread of the gypsy moth into New Hampshire by the large amount of automobile traffic along the main road from Newburyport, Mass., to Portsmouth, N. H., in December, 1904, the writer had the trees along it examined through the towns of Seabrook and Hampton Falls by two trained assistants. No traces of infestation, however, were found at this time. Inspection during the present fall shows that no infestation along this road existed in 1904.

In September, 1905, the inspectors of Massachusetts had located the pest in all of the towns along the northern boundary of Massachusetts from Methuen eastward, and discovered that it had existed in Newburyport since 1904. It was, therefore, apparent that the neighboring towns of New Hampshire were undoubtedly infested. Through the courtesy of the Massachusetts superintendent for suppressing the gypsy moth, Mr. A. H. Kirkland, we secured the services of one of the most experienced of the Massachusetts inspectors, who, in company with our assistant, Mr. W. P. Flint, inspected all the towns along the coast from the Massachusetts line to and including the City of Portsmouth. The pest was found in all of these towns, though only the main road and the village streets were examined, except in Portsmouth, where practically the whole city was inspected. But a small portion of each town was, therefore, examined, merely enough being inspected to establish the existence of the pest and something as to its relative abundance. One or two examinations of back roads, not so much travelled as the main road, revealed, however, the presence of eggs along them. In two of these infestations the pest had been introduced in 1904, from 25 to 30 egg masses were found this year, and the caterpillars had spread from the original point to nearby orchards, 200 yards distant. The number of infestations found and their nature were as follows:

In town of Seabrook, 14 infestations; 21 egg "nests," two pupal, or larval, skins.

In town of Hampton Falls, six infestations, eight egg "nests."

In town of Hampton, 14 infestations; 17 egg "nests."

In town of North Hampton, five infestations; 30 egg "nests" (one nest of 1904).

In town of Greenland, one infestation; one pupa skin.

In town of Rye, seven infestations; 35 egg "nests" (one nest of 1904); two pupa skins.

In City of Portsmouth, two infestations; three egg "nests."

Total: In seven towns inspected, 49 infestations; 114 egg "nests"; five pupal skins; two egg "nests" of 1904.

The infested points are indicated upon the map (Figure 1). It is interesting to note that practically all of the infestations were on apple trees. In all cases the egg masses were immediately creosoted, so that the pest is probably exterminated over all the immediate territory actually examined, all trees being examined for 200 feet back from the roads, though an inspection next year will be necessary to determine that no scattered eggs may have developed. The Cities of Exeter and Nashua were also thoroughly inspected, but no trace of gypsy moth was found. It might be thought possible that any of the territory within the same radius from the worst districts in Massachusetts as Portsmouth might be found infested, but this is hardly probable. The summer travel along the coast much exceeds that up the Merrimack Valley or toward Exeter. Indeed, in Massachusetts the spread has been much faster to the northeast and the pest has not been found in Lowell. It seems fairly safe to conclude, therefore, that infestation in New Hampshire is probably confined to Rockingham County east of the Western Division of the Boston & Maine Railroad. It is of the utmost importance that the towns in this district which have not been inspected be examined, including Atkinson, Hampstead, Newton, South Hampton, Kingston, Newington and also Dover and Rochester in Strafford County, as the latter are on the route of automobile travel to the mountains.

FOOD PLANTS AND INJURY CAUSED.

"The gypsy moth caterpillar will attack all fruit, shade and woodland trees. It shows a preference for the apple, white oak, red oak, willow and elm. It will devour on occasion nearly every useful grass, plant, flower, shrub, vine, bush, garden or field crop that grows in Massachusetts (or New Hampshire).

"The caterpillar kills both deciduous (or hard-wood) and coniferous (soft-wood or evergreen) trees. Woodlands assailed by it in formidable numbers are stripped bare, as

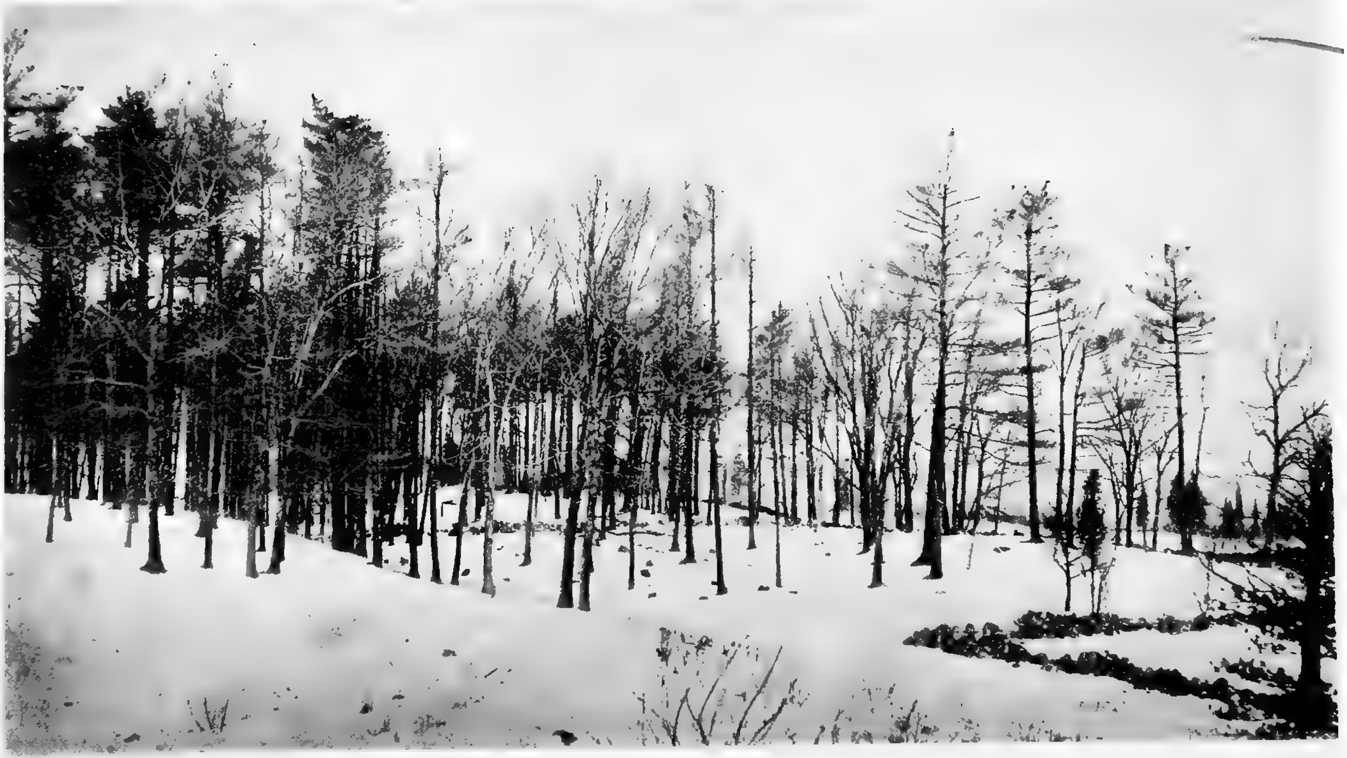


FIG. 10.—A piece of woodland at Arlington, Mass., typical of many, killed by defoliation by Gypsy Moth caterpillars in 1904. Taken March, 1905

in winter, and many trees are killed. While several consecutive strippings are usually necessary to cause the death of a healthy deciduous tree, one thorough stripping will kill the white pine and other coniferous trees.'' Figure 10 shows the effect of a single stripping upon pine and spruce at Arlington, Mass., in 1904, the photo being taken by the writer in March, 1905. These trees were totally dead and fit only for firewood. Throughout acres of woodland in the worst infested district in Massachusetts the pines, spruces and hemlocks have been almost entirely destroyed and the piles of cordwood attest the devastation wrought by the gypsy moth caterpillar. ''Where the gypsy moth abounds in residence districts, it not only eats nearly everything green, but it swarms, in caterpillar form, upon houses, walks and verandas and often enters dwellings. In residential districts most heavily infested by the moth real estate tends to rapid depreciation, so that it sometimes becomes a matter of difficulty to rent or sell property.'' Such instances now exist, as shown to the writer.

NATURAL ENEMIES.

''While the gypsy moth is a serious enemy of trees, it has its own foes in the shape of predaceous insects, parasites and birds. Several ground beetles prey on the caterpillars, while true parasitic insects attack both larvæ and pupæ. Several species of birds, notably vireos and cuckoos, consume large numbers of the caterpillars, while others, like the chewink, chickadee, blue jay and crow, do their part in reducing the numbers of the pest. The service of these natural tree protectors is worthy of high praise, but in attempting to control the moth the main reliance must be placed on human efforts—on the timely and thorough application of the remedial measures outlined'' below. As yet the native enemies have not shown ability to materially check the increase of the pest.

It is well known that in Europe the insect seems to be largely controlled by its natural enemies, so that serious outbreaks occur but once in a number of years in any one locality, in the same manner as do outbreaks of our native insects, such as the forest tent caterpillar or white-marked tussock moth, which are controlled by native parasites. A determined effort is, therefore, now being made by the Massachusetts superintendent, in coöperation with the Bureau of Entomology of the United States Department of Agriculture, in importing those parasites and predaceous insects which prey upon the gypsy moth in Europe. Already large numbers have been imported from all parts of Europe and are being carefully reared in strict confinement at Saugus, Mass. It is the hope of everyone that these importations may result, within a few years, in such an increase of these enemies that they will be able to control the gypsy moth. It is the belief of the writer that ultimately either imported or native enemies of the gypsy moth will control it, as they do our native insects; but Nature works slowly, and whether such a condition will arise in five, ten or

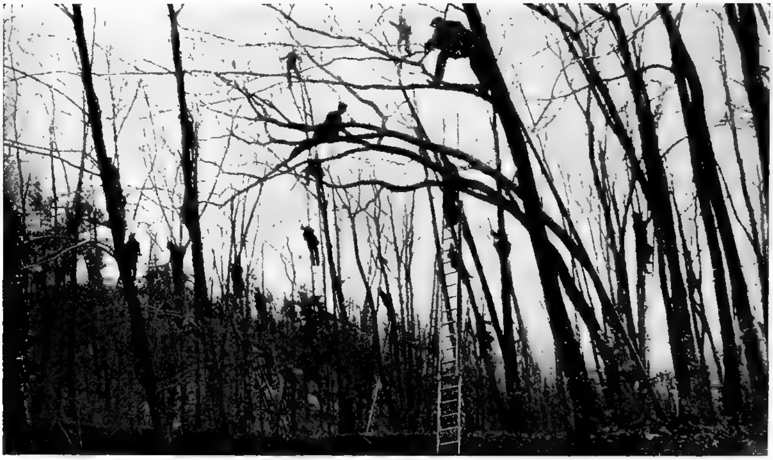


FIG. 11.—Killing the eggs of the Gypsy Moth in woodland, showing the large amount of labor and expense involved in combating the pest in badly infected districts. (After Forbush and Fernald.)

one hundred years, it is impossible to predict, as we have no experience with imported pests of a nature sufficiently similar to furnish us any precedent for comparison. Obviously, therefore, it will be folly to place any dependence upon these natural enemies until their value and ability to even partially control the gypsy moth is clearly established, for meantime, if not controlled by the means already well known and which have been found effective, a condition might arise which would make it impossible to cope with the pest and we would be left comparatively helpless in attempting to control it in woodlands and forests.

REMEDIES.

Killing the Eggs.—"No single method of destruction against the gypsy moth is more effective than killing the eggs. The egg masses, wherever accessible, can be killed from August to May by soaking them thoroughly with creosote mixture. The creosote may be applied with a small swab or paint brush. In killing gypsy moth eggs in high trees, it is usually best to work with two men; one man to point out the egg clusters from the ground, another to kill the eggs in the trees. (Figure 11.) Creosote mixture may be purchased at agricultural warehouses and seed stores at from 50 cents to $1 per gallon, depending on the quantity."

CATERPILLAR DESTRUCTION.

Spraying.—"Spraying with arsenate of lead at the rate of 10 pounds to 100 gallons of water is very effective when the caterpillars are small. Any of the common hand outfits will suffice for the spraying of shrubs or flowering plants, but for use on trees a barrel pump is desirable. The poison should be thoroughly mixed in water and applied, if possible, on a clear day, in such a manner as to cover the leaves rather slowly, with a fine mist. The foliage should never be drenched with a stream. When the leaves begin to drip spraying should cease at once. Spraying should begin at the top of the trees. The work is most effective when done during May and early June.'' Where orchards are to be sprayed, this spraying may be combined with that which should always be given for the codling moth and diseases.

Burlapping.—''When a loose band of burlap or other cloth is tied about an infested tree trunk, the caterpillars will gather under it in the early morning and may be destroyed by hand. The burlaps should be examined daily.'' ''This cloth band is in no sense a tree protector; nor is it a trap. Its function is simply to give the shelter which the caterpillars seek by day.'' Unless carefully attended the burlap band does more harm than good. All burlaps should be removed at end of season.

NECESSITY OF THE SUPPRESSION OF THE GYPSY MOTH IN NEW HAMPSHIRE.

It is absolutely essential that the towns in New Hampshire known to be infested with the gypsy moth, or which are liable to be infested, should take immediate action toward having all trees along roadways carefully inspected by a trained man and the egg nests destroyed wherever found.

It is difficult to appreciate the necessity of fighting such a pest as this where it is present in such small numbers as to do no damage, unless one has seen the terrible devastation wrought by it when at its worst. Citizens of southeastern New Hampshire are coming to appreciate, through personal experience, the seriousness of the brown-tail moth caterpillars, but in many respects the gypsy moth is a much more serious pest. It defoliates the trees in June, when it is much more difficult for the tree to put out new leaves, and it is more injured than by defoliation by the browntail caterpillars earlier in the spring. Again, the gypsy moth caterpillar attacks pines and all coniferous trees. Should it become established in New Hampshire as in eastern Massachusetts, we have every reason to think that it would cause immense losses to the lumber industry throughout New Hampshire. Unless the spread of the gypsy moth is checked and it is prevented from reaching north of Rochester, there is every reason to believe that it would do more than all the lumbermen to destroy the scenic beauty of the White Mountains, and a national forest reserve would not prevent its depredations.

As before stated, no funds of the state or of this station are available for further inspection of towns other than that already partially made to determine, as far as possible, the present extent of the infestation. It is imperative, therefore, that each town takes steps for the eradication of the pest within its borders. This should be done by the towns and not left to the individual, for but few people unacquainted with the pest and untrained in looking for it will be able to find a single egg mass in an orchard of 100 trees, as a trained inspector will readily do. The importance of such work being done thoroughly by the town or state and not left to the property owner is indicated by the experiences in Massachusetts. The statements of two citizens quoted in the exhaustive treatise on "The Gypsy Moth," by Messrs. Forbush and Fernald, bear directly upon this: "It is not easy to give outsiders an idea of how bad the caterpillars were. If the state had not done something, I honestly think we should have had to move away from here. We were worn out with catching them. When they were thickest we did not pretend to go out the front door at all." Another says: "Before public measures were taken in the matter, the foliage was completely stripped from all the trees in the eastern part of our town, presenting a picture of devastation and promising in a short time to kill every tree and shrub and all vegetation in any region visited by them; which shows how inadequate individual effort was to cope with the subject." Many others might be quoted in the same strain.

If the establishment of the gypsy moth in New Hampshire is to be prevented, it will be necessary for the towns to destroy any eggs existing in parts not inspected by us before May, 1906. Similar inspection will doubtless also be necessary in the winter of 1906–1907, as caterpillars will probably again be brought in from Massachusetts as long as the pest exists in the enormous numbers now present there. It is to be hoped, however, that the Legislature of 1907 will enact laws and appropriate funds whereby this and other serious insect pests may be controlled by agents of the state after that time.

Let every citizen who loves and is proud of the grand old shade trees which line the highways of New Hampshire; let every farmer and fruit-grower who wishes to prevent a future heavy tax in combating this pest in his orchards; let every lover of the mountains and forests of the Granite State, join in securing immediate action by the towns in which it is now necessary and in securing suitable state, and if, as now seems necessary, national legislation by the present Congress, to secure the control and prevent the future spread of this pest, which has caused such serious devastation and which, if not controlled within the next year or two, may bring about conditions which no one can predict.

(NOTE.—The writer will be glad to identify any eggs which may be thought to be those of the gypsy moth. In all cases where they are found tightly adhering to the bark, they should be saturated with creosote before removing from the tree, else some may be scattered and sufficient live eggs be left to propagate the pest for another season.)

For the most complete accounts of the gypsy moth published, see: Howard,—Bulletin 11, new series, Division of Entomology, United States Department of Agriculture; Forbush and Fernald, The Gypsy Moth, pp. 495, etc., plates 66: Massachusetts State Board of Agriculture (1896); Kirkland,—Bulletin 1, Office of Superintendent for Suppressing Gypsy and Brown-tail Moths. (Boston, 1905.)

Vermont Agricultural Experiment Station

BURLINGTON, VT.

CIRCULAR No. 2

March, 1909

THE GYPSY AND BROWN TAIL MOTHS

WM. STUART, HORTICULTURIST

The Gypsy and Brown Tail moths have spread from Massachusetts to New Hampshire and other New England States. Immense sums of money have already been spent in an attempt to prevent further devastation. These facts quite naturally have caused alarm in Vermont, especially near the Massachusetts and New Hampshire borders; alarm manifested during the last year or two by the large numbers of insects sent to the Station, believed to be either the Gypsy or the Brown Tail moth. In no instance were the fears of the sender warranted. The writer has no personal knowledge of their invasion of Vermont. How long this statement may hold true cannot be foretold; but it is clear that the chance of infestation increases with their greater spread. *The earlier the State is informed of their arrival, the easier, the less costly and the more certain their extermination. Hence the residents of counties bordering on Massachusetts or New Hampshire territory should be especially observant of all unfamiliar caterpillars or moths.* When doubt exists they should be at once forwarded to the Station for identification. The Station will at once notify the Commissioner of Agriculture if as a matter of fact the specimen sent is of either species[1]. It is suggested that inasmuch as the present incumbent of that office is not an entomologist specimens be submitted to the Station rather than to him, in the interests of saving time and obviating the necessity of their transshipment. Place name and

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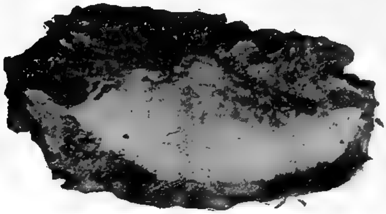
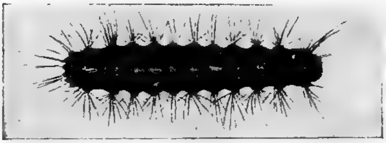
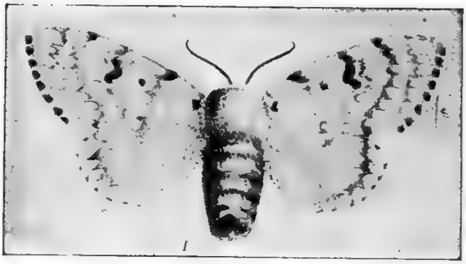
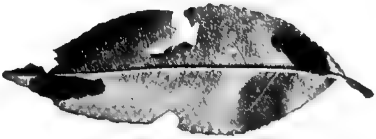
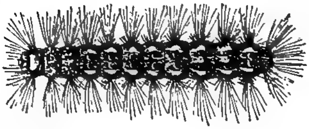
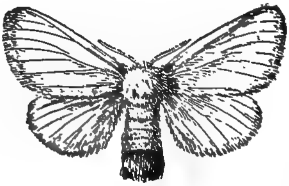
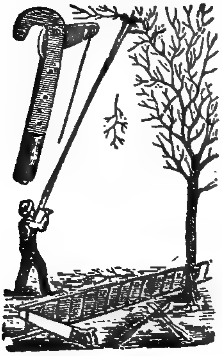
[1] Acts of 1908, No. 11, Sec. 8 (in part): Sec. 8. "Said commissioner may use such means as in his judgment are necessary to exterminate or prevent the introduction of the San Jose scale, the gypsy moth, the brown tail moth and any other threatening and unusual insect pest found to be injuring vegetable growth."

THE STAGES AND LIVES OF THE GYPSY MOTH

Stages.	Gypsy Moth.
Egg Cluster .... 	Usually on bark of tree; very rarely on leaf. Robust, 1½ to 2 inches long. Light yellow or creamy. From August to May.
Caterpillar. Full grown.......... 	Dark grayish or sooty. Double row of five pairs of blue, followed by six pairs of red spots along back.
Moth. Female................................ 	Wings spread 2¼ in. Dingy-white, lightly streaked and blotched with blackish. No brush of brown hairs at tip of abdomen. Does not fly, crawls.
Winter Passed........................	In egg stage—see above. Never as a caterpillar.
Irritation of Human Skin..........	Not caused by any stage.
Most Effective Means of Control. Soak eggs with creosote in fall, winter, or spring.	

AND BROWN-TAIL MOTH CONTRASTED.

Brown-Tail Moth.	Stages.
Always on under side of leaf. Smaller and more slender. Dark or golden brown. July.	Egg Cluster. 
Bright tawny or orange. A conspicuous row of pure white spots or dashes along each side of body. Only two bright red spots on middle line at lower end of back.	Caterpillar. 
Wings spread 1½ inches..... Pure snow white. A conspicuous, sharply contrasted, thick tuft or patch of golden or brownish hairs at tip of abdomen. . . A swift, strong flyer, by night, and attracted to lights.	Moth, Female. 
As small caterpillars in a silken web or nest on tips of twigs, from which they crawl out in spring.	Winter Passed.
	Irritation. Hairs from caterpillars, which are often transferred to cocoons and moths, cause an annoying and painful irritation of the skin. Most Effective Means of Control. Cut off and burn webs in winter.

postoffice address on packages. Specimens sent through the mail should be carefully enclosed in a package which is not easily broken or crushed, such as a wooden or tin box[1].

The food plants of these caterpillars in badly infested areas include the foliage of practically all deciduous trees. The Gypsy caterpillars usually attack forest and shade trees, while the Brown Tail prefers the foliage of the pear and apple.

The most marked difference in the life histories of these two insects, as noted in these illustrations[2], is shown in their winter habits. The Gypsy passes the winter in the egg, the Brown Tail as a young caterpillar. The distinct and characteristic markings of the full grown caterpillars and moths enable one to determine identities fairly well.

Methods of Distribution. The Brown Tail moth is best adapted by nature to spread over a wide area, for the female moth can fly to considerable distances, whereas the female Gypsy moth has very slight use of its wings. The usual methods whereby the latter are distributed are by the falling of the caterpillars onto passing vehicles (horse, automobile, trolley), they being thus borne considerable distances. The same means, of course, serve the Brown Tail as well.

Be on the watch for Gypsy and Brown Tail moths, especially in Windsor and Windham Counties, along the lower Connecticut River towns and the Massachusetts border.

Every New England State but Vermont now harbors these pests. The earlier they are combated, the shorter and more successful the battle.

Study the illustrations and descriptive matter and compare with specimens you may find.

Notify the Experiment Station, Burlington, Vt., if you think you have found either. Send specimens enclosed in a secure package, bearing name and address of sender.

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[1] Sending insects by mail improperly packed is an offense against postal laws.

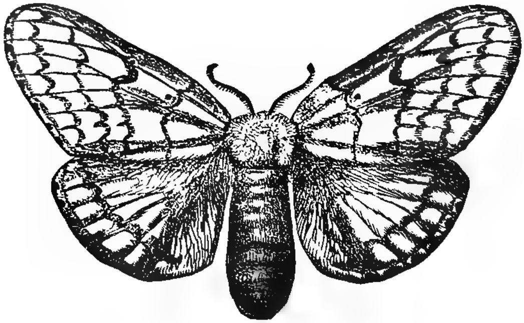
[2] Furnished through the courtesy of the New Hampshire Experiment Station.

CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONN.

BULLETIN 153, MARCH, 1906.

ENTOMOLOGICAL SERIES, No. 13.

The Gypsy Moth and the Brown-Tail Moth.



FEMALE GYPSY MOTH.
(After Howard, Bur. of Ent., U. S. Dept. of Agr.)

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The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

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The Gypsy Moth and the Brown-Tail Moth.

BY

W. E. BRITTON,

State Entomologist.

Connecticut Invaded by the Gypsy Moth.

The gypsy moth is already in Connecticut, specimens having been found at Stonington, and the entomologist is now hunting and destroying the egg-masses. Everything will be done to exterminate the pest in this locality.

THE DANGER TO CONNECTICUT.

There is good reason to fear that both of these pests will soon bring havoc to the woodlands of the state. The gypsy moth attacks all kinds of trees including pines and other cone-bearing trees, which are ruined by defoliation much sooner than deciduous trees. Fruit and shade trees suffer alike.

The brown-tail moth attacks fruit trees and some of the woodland trees, devouring the leaves; it is also a great nuisance, as the larval hairs break off, and on coming in contact with the human skin, cause extreme irritation and sometimes illness.

WHAT TO DO.

It is earnestly requested that any suspected specimens of eggs, caterpillars or adults be called to the attention of the State Entomologist of this station in order that he may identify them. He will cooperate, so far as he is able, in checking and exterminating these dangerous and destructive enemies of all trees and shrubs. Directions for combating these insects will be found in the following pages.

TRANSPORT NO LIVING INSECTS.

It is against the United States laws to send living insects by mail, and violations of the law are punishable by a heavy fine and imprisonment. It would be dangerous to send such pests as the gypsy or brown-tail moths in any stage of their existence, if alive. All insect specimens should therefore be killed before sending them to be identified.

Eggs, pupæ and larvæ can be killed by dropping them into a jar of alcohol, benzine or gasoline and leaving them for a few hours. When removed the liquid evaporates and they are in good shape for identification. Beetles, bugs and scale insects can be treated in the same way. Moths and butterflies may be killed by the fumes of cyanide, chloroform, ether, carbon bisulphide, or they may be submerged in gasoline or benzine, which kills them quickly without injuring them for the purpose of identification. They should be packed in a tin, wood or strong pasteboard box which will not be crushed in transit.

THE GYPSY MOTH.

Porthetria dispar Linn.

An outbreak of the gypsy moth in Eastern Massachusetts was met by an appropriation by the Legislature of that state for the purpose of suppressing the insect. Exterminative work was commenced in 1890 and kept up for ten years, when it was discontinued. During this period over $1,000,000 was expended and the insect was so far checked that it was doing little damage in 1900. In 1905 the pest had spread over so much territory and had become so troublesome that the commonwealth again took the matter in hand, and is endeavoring to control the insect under the superintendence of Mr. A. H. Kirkland, an appropriation of $300,000 being available to carry on the work until May, 1907.

At the present time the insect is found throughout the eastern portion of Massachusetts, southeastern New Hampshire, and a region in and about Providence, R. I., is known to have been infested for two years or more. It has been reported several times in Connecticut, but always proved to be some other species. In July, 1905, two adult female moths were taken and two males were seen by Mr. E. Frensch at Stonington, and recently egg-masses have been found in the same locality.

Life History and Injury.

The eggs are laid, usually on the trunks and branches of trees, in July and August, in oval masses each containing about 500 eggs and covered with hair as shown in Figure 1.

The eggs hatch about May 1st, and the young caterpillars soon begin to feed upon the expanding foliage, devouring all kinds of vegetation, even defoliating coniferous trees. All the damage is done in this stage. As the caterpillars approach maturity, they feed mostly at night, and seek shelter during the day on the shady side of the trunks, under fence rails, stones and rubbish, where they may often be found in large numbers.

When full-grown, the caterpillar is between two and three inches long, dark brown, with two rows of red spots and two rows of blue spots along the back, and is covered with long hairs. (See Figure 2.) The caterpillar usually reaches full size in July, and transforms to a pupa or chrysalis, usually spinning a few threads about itself, as is shown in Figure 3.

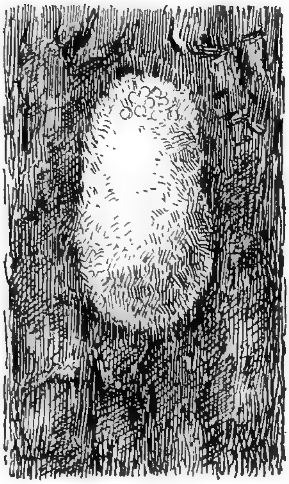

FIG. 1.—Egg-mass of gypsy moth.
(After Kirkland.)

During the latter half of July the adult moths emerge, mate, and the females lay eggs. The brown male has a wing expanse of one and one-half inches, and flies about in the daytime in a zigzag course. The female has a heavy body, and does not fly far, though furnished with wings which expand about two inches, and which are nearly white, with delicate black markings. See front page of this bulletin. The male is shown in Figure 4. There is but one brood each season.

Means of Distribution.

As the caterpillars of both species crawl about in going from one tree to another, they are very apt to invade freight cars on the siding, and be carried to other places. Both kinds of caterpillars have the habit of spinning down on slender threads from their food trees, and may thus drop on carriages, automobiles or railroad cars, and be carried long distances into a part of the country heretofore uninfested.

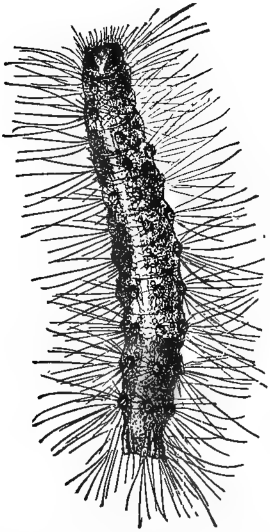

FIG. 2.—Gypsy moth caterpillar.
(After Howard, Bur. of Ent., U. S. Dept. of Agr.)

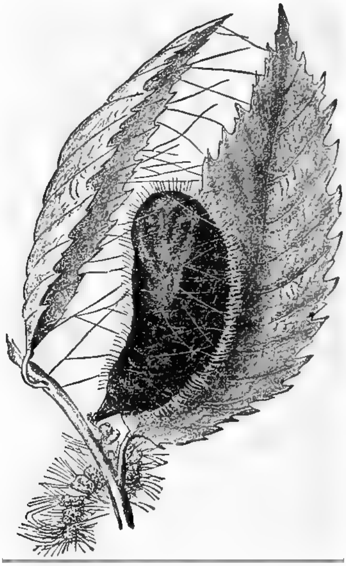

FIG. 3.—Cocoon of gypsy moth.
(After Howard, Bur. of Ent., U. S. Dept. of Agr.)

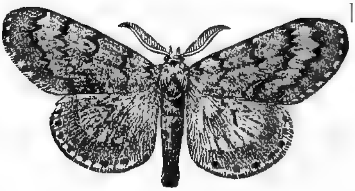

FIG. 4.—Male gypsy moth.
(After Howard, Bur. of Ent., U. S. Dept. of Agr.)

Natural Enemies.

There are several species of parasitic Hymenoptera, Diptera and predaceous insects that attack both the gypsy and brown-tail moths in Massachusetts, and they are also devoured by birds, toads, and other insectivorous animals. But all of these working together do not control the pests.

Importation of Parasites.

In Europe, the native home of these insects, there are a larger number of parasitic enemies belonging to species not found in this country. During 1905, Dr. L. O. Howard, the Government Entomologist, in coöperation with the Massachusetts authorities, collected in Europe some of the parasites of the gypsy and brown-tail moths, and sent them to Massachusetts, where they will be reared and finally distributed in the infested region. Of course these parasites may not be able to thrive, or even to live, in this country, but it is an experiment worth trying, and we certainly hope for much benefit from it.

Remedial Measures.

One of the most effective means of controlling the gypsy moth is by destroying the egg-masses on the trunks and branches of trees, on fences, stones, or wherever they occur. A sponge, brush or swab is dipped in creosote mixture, and the egg-masses are saturated with it. A long pole can be used to reach the egg-masses, but it is often necessary for men to climb about in the trees in order to reach them. Where brush land is badly infested, it is often best to cut and burn the brush between August and May to destroy the eggs. Spraying the foliage with arsenate of lead, using 5 pounds to 50 gallons of water, will of course save the trees from injury for the season. This poison adheres to the tree for a long time, and will not injure the leaves. Paris green can be used at the rate of one pound in 100 gallons of water, but two pounds of lime should be added to prevent injury to the foliage. This mixture will not adhere to the leaves as well as arsenate of lead.

The caterpillars can be gathered and destroyed while resting on the tree trunks or hiding under rubbish during the day. The chrysalids or pupae will be found in similar places, and can also be destroyed by heat or by crushing.

THE BROWN-TAIL MOTH.

Euproctis chrysorrhaea Linn.

This insect was first noticed in Somerville, Mass. in the early nineties, but was supposed to be some native species. It increased in abundance, and was brought to the attention of entomologists in 1897, who found it to be the brown-tail moth, a European pest introduced probably by accident into this country. A special appropriation was granted by the Legislature for fighting this insect, and the matter was placed in charge of the Gypsy Moth Commission, but all work of the Commission was discontinued in 1900. The brown-tail moth has spread rapidly to the north through Southeastern New Hampshire, Maine, and adults have been captured in St. John, New Brunswick, but may have been carried there by boats from Boston. The spread southward has been less rapid, Cape Cod being the most southerly point known to be infested. Toward the west the insect has reached Amherst, Mass.

Habits and Life History.

The eggs are laid in masses of about 300, on the under side of the leaves, the egg-masses being smaller and more elongated than those of the gypsy moth. They are also more of a reddish color, but are covered with hair in much the same manner. Egg-laying takes place between the middle and the end of July.

The eggs hatch early in August, and the young caterpillars feed gregariously upon the upper leaf surface, but soon begin to fasten a number of leaves together with silken threads which they spin, forming a nest or web on the ends of the small branches. On the approach of cold weather, about 250 caterpillars enter each web, and remain there, about one-fourth grown, through the winter, coming out early in April and feeding upon the buds, and later the opening blossoms and leaves. The caterpillars feed during the day, and attack a large number of plants, preferring pear, cherry, apple and other fruit trees, but also attacking shade and forest trees, especially the oak. Large trees are often stripped of their leaves.

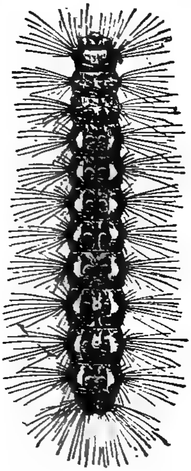

FIG. 5.—Caterpillar of brown-tail moth.
After Fernald.)

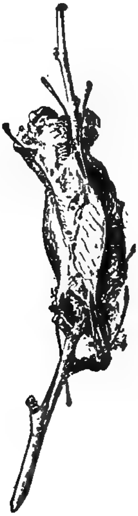

FIG. 6.—Web or winter nest of brown-tail moth.
(After Fernald.)

When full-grown, the caterpillars are about two inches long, dark brown with an interrupted white stripe on each side, and two conspicuous red dots on the back. They are covered

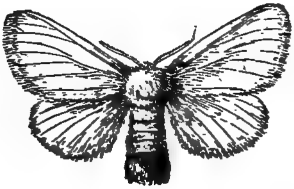

FIG. 7.—Female brown-tail moth.
(After Fernald.)

with long hairs which are finely barbed and brittle. These break off, and, on coming in contact with the human skin, cause great irritation and sometimes serious illness. The full-grown caterpillar is represented by Figure 5, and Figure 6 shows the appearance of the web or winter nest.

The caterpillars become full-grown the last of June, make their cocoons at the tips of the twigs, often in a bunch of leaves, and the moths emerge two weeks later, or about the middle of July.

The moths are pure white except the end of the abdomen, which is brown, giving it the name of brown-tail moth. The female has a wing spread of about one and one-half inches, while the male is somewhat smaller. (See Figure 7.) Both sexes fly at night, and may be taken around electric lights.

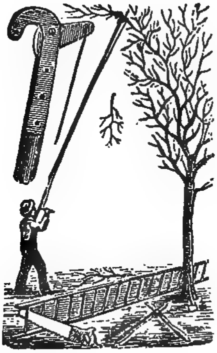

FIG. 8.—Tree pruner.

Means of Control.

The best of all remedies against this insect is the destruction of the caterpillars in the winter webs or nests. The winter nests can be readily seen on the twigs throughout the winter, and these should be clipped off with a long-handled tree pruner such as is shown in Figure 8, and gathered and burned. The caterpillars are hibernating in these nests from October to April. It is of no use to cut off the nests and leave them on the ground, as the caterpillars may remain uninjured. All should be gathered and burned.

Spraying with poison, as has been described for the gypsy moth, can be practiced; the brown-tail caterpillars are more susceptible to the effect of poisons than the gypsy caterpillars.

Caterpillars which are crawling about in great numbers on trees, fences, etc., should of course be destroyed. Sprinkling with kerosene, either pure or in an emulsion, or even with strong soapsuds, is of considerable value in destroying them.

Issued Ja

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 275.

THE GIPSY MOTH AND HOW TO CONTROL IT.

BY

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ENTOMOLOGIST.

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1907.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., December 14, 1906.

Sir: I have the honor to transmit a brief account of the gipsy moth (*Porthetria dispar*), with some consideration of methods of control, which I believe is suited for publication as a Farmers' Bulletin.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE GIPSY MOTH AND HOW TO CONTROL IT.

INTRODUCTION.

The gipsy moth (*Porthetria dispar* L.) is an European insect which was accidentally introduced into Massachusetts nearly forty years ago and has since spread rather slowly, being still confined to the eastern part of Massachusetts, to Rhode Island, to the southern part of New Hampshire, and to more or less isolated localities in eastern Connecticut and southwestern Maine.

After the discovery of its presence, in 1889, the State of Massachusetts for a number of years kept up a vigorous effort to exterminate the insect, and this effort was supported by large appropriations, but was abandoned in 1900. In 1905 appropriations were again made for the purpose of attempting to suppress this insect and the brown-tail moth,[a] and these appropriations are still in operation.

Although appealed to on several occasions, the National Government took no steps to assist the State of Massachusetts in its fight against this destructive species—with the exception of a small appropriation made in 1905 for the purpose of introducing its natural enemies—until the present year. At the first session of the Fifty-ninth Congress, however, the sum of $82,500 was appropriated, to be expended by the Secretary of Agriculture, through the Bureau of Entomology, in an effort to prevent the further spread of the gipsy moth and the brown-tail moth. Under this appropriation active work is now going on in parts of New England, and the character of this work is explained in a later section of this bulletin. A popular consideration of the brown-tail moth has been published in Farmers' Bulletin No. 264, and the present bulletin is planned for the purpose of presenting in concise form what is known at the present time about the gipsy moth.

THE GIPSY MOTH IN EUROPE.

The gipsy moth has a wide distribution throughout middle and southern Europe, western Asia, and northern Africa, reaching from Stockholm on the north to Algiers on the south, and to England on the west. It extends across to eastern Asia, including Japan, and has been found in Ceylon. In a large portion of its European range the gipsy moth is occasionally abundant and injurious; but these injurious outbreaks occur only at intervals, and in many portions of its range it becomes noticeable only very rarely. For the most part, it is satisfactorily held in check by its natural enemies.

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[a] See Farmers' Bulletin No. 264, U. S. Dept. Agric., 1906.

INTRODUCTION INTO AMERICA AND SUBSEQUENT SPREAD.

Unlike the brown-tail moth, the precise time and method of introduction of the gipsy moth is well known. Prof. Leopold Trouvelot, in 1869, was connected with the astronomical observatory at Harvard University, and, for his pleasure and interest, was engaged at odd times in the study of wild silkworms, with the idea that species of commercial value might be found, and that perhaps something might be done in the way of cross breeding to produce a hardier insect than the silkworm of commerce, and one which, perhaps, might prove to be resistant to the pebrine disease which at that time was playing havoc in the silkworm establishments of Europe. He imported different silk-spinning caterpillars in different stages of existence, and among others egg clusters of the gipsy moth. He lived at 27 Myrtle street, Medford, and raised caterpillars on a shrub in his dooryard, inclosing them with a net. During a gale the net was torn and the insects scattered. He searched for them, and destroyed those found; he also gave notice of the probable escape of the species, but the affair was soon forgotten. For many years the insect was not noticed by the people of Medford, and it probably increased very slowly. It is supposed that it was gradually accommodating itself to the climate, and it is known that the neighborhood abounded with insectivorous birds and that adjoining wood lots were frequently burned over. Eventually the insect became noticeable, and by the summer of 1889 had multiplied to such an extent as to become a notorious pest; then for the first time specimens were sent to the State agricultural experiment station at Amherst and determined by Dr. H. T. Fernald as the well-known gipsy moth of Europe.

The town of Medford raised a sum of money to fight the insect, and in the spring of 1890 the State appropriated $25,000, an additional $25,000 being appropriated early in June. Other appropriations followed from year to year with gradually increasing amounts, and admirable work was done under the Massachusetts State board of agriculture by Mr. E. H. Forbush in charge of the field operations, and Prof. C. H. Fernald in charge of the scientific and technical work. The last appropriation was expended in 1899, and the legislature refused to vote further sums for 1900 and the following years. In 1905 the appropriations were renewed, and the work has since been carried on under a well-founded State law, the provisions of which are summarized in the concluding section of this bulletin.

The accompanying map (fig. 1) indicates accurately the infested district of Massachusetts at the time of the interruption of the State work in 1900. It also shows the district found infested in 1906, when the work of suppression was recommenced by the State. The interruption of the work is thus seen to have been almost disastrous. In 1899 the State board of agriculture had the problem well in hand, and at that time it seemed very probable to skilled practical entomologists who looked into the matter that even extermination was possible in the course of a comparatively short time. But the five years' interruption of the work caused the spread of the insect from a restricted

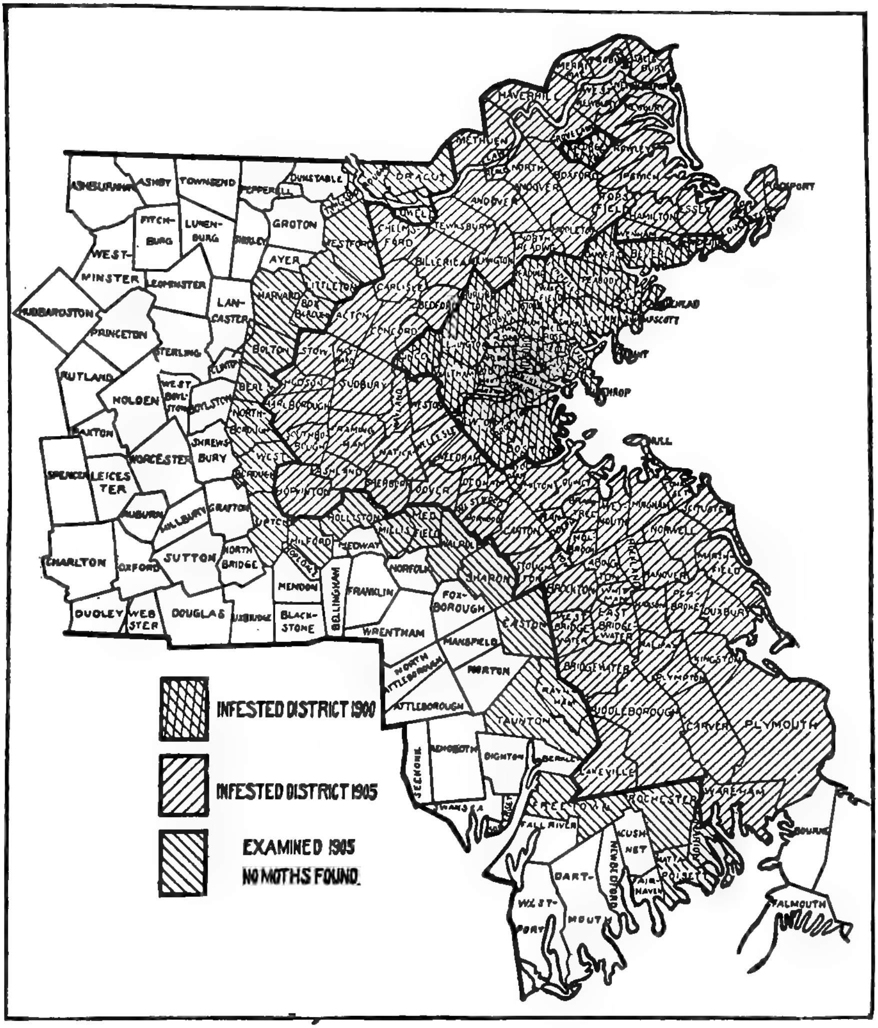

FIG. 1.—Districts in Massachusetts infested by the gipsy moth in 1900 and 1905. Infested area in 1900, 359 square miles; in 1905, 2,224 square miles. (From Kirkland.)

territory of 359 square miles throughout an extended range of 2,224 square miles. Beyond the limit indicated as that of 1905 the moth has probably not spread to any very great extent within the limits of the State of Massachusetts. Scouting work, however, during the early spring of 1906 and the autumn of the same year has indicated a general spread over the New Hampshire border into the southern tier of counties of that State, and recent scouting in Maine has shown the establishment of the gipsy moth at several points in the southwestern portion of that State. Moreover, it has been found near Stonington, Conn., and over a considerable space within and about the city of Providence, R. I.

THE TERRITORY NOW INFESTED IN THE UNITED STATES.

The territory at present infested may be briefly considered by States as follows:

Massachusetts.—The gipsy moth has been found in Massachusetts by the local State force in 138 cities and towns, which represent an area of about 2,480 square miles. The most seriously infested section is a group of about twenty towns just north of Boston, including a territory surrounded by Salem, Peabody, Lynnfield, Wakefield, Stoneham, Woburn, Lexington, Waltham, Watertown, and Cambridge. Within this territory almost every tree is more or less infested. Thousands of fruit trees and shade trees have been killed by this pest; in the woodlands one can easily find blocks of from 1 to 50 acres in which almost every tree is dead. During the past summer several thousand acres of these woodlands were entirely denuded of foliage. The voracious feeding of the gipsy-moth caterpillars year after year must soon cause the loss of other large areas of woodland.

Outside the badly infested area mentioned above the gipsy moth occurs in less alarming numbers, until in some of the outside towns it is only discovered after a most careful search.

The territory to the south of Boston, except the city of Quincy, is not known to be infested to a serious extent, although the moth has been discovered south to Buzzards Bay and east to Orleans. In most of the towns in this southern district there are from three or four to one hundred or more colonies. While no serious damage has yet resulted from the presence of the moth in this section of the State, the infestations are there, and unless strenuous measures are resorted to this territory will in a few years be devastated as severely as has been the country to the north of Boston.

The country to the west and north of the badly infested central region, while quite seriously infested in spots, shows the moth in decreasing numbers as we diverge from this center. The infestation extends as far west as Westboro and Ayer and north all along the New Hampshire border.

Under the State laws of Massachusetts and through its liberal appropriations, the trees on the streets and in the residential sections of the cities and towns have received sufficient attention to prevent any serious damage this year.

New Hampshire.—In New Hampshire the presence of the gipsy moth in small numbers was known in the autumn of 1905 in all of the seacoast towns and in the city of Portsmouth, but little systematic work was done until August of this year, since which time employees of the Bureau of Entomology have discovered the moth widely scattered in eight towns, which are all that have been thoroughly scouted. This territory includes Greenland, Portsmouth, Seabrook, Hampton Falls, North Hampton, and Rye. Effective scouting, however, can be done only after the leaves fall, and that now going on will probably reveal the presence of the insect over a much larger area.

Maine.—During the early autumn the gipsy moth was reported in Kittery, Me., since which time a careful scout has been made of Kittery, Eliot, and York, in all of which towns the insect has been discovered, with the probability that it will be found in other towns. Systematic scouting work is being continued in this State.

Rhode Island.—The gipsy moth was discovered in Providence, R. I., in 1901, and during that summer the city made some effort toward its eradication. From 1901 to 1906 very little work was done, and during that period the moth has spread until it now abounds in nearly every portion of the city, occurring in the largest numbers in the northeastern and southwestern sections. It has spread also into the adjoining towns of Cranston and Johnston.

There are several small but very bad colonies in Providence, some of which show infestation almost equal to the badly infested places in Massachusetts. Most of the known infestation is confined to city property, and, unless large colonies of the moth are discovered in the woodlands, a continued, aggressive campaign should result in the extermination of the pest in this territory.

Connecticut.—In the summer of 1905 the gipsy moth was discovered in Stonington, Conn., and, so far as known, it is confined to an area of about 1 square mile to the north and east of Stonington Village. During the winter of 1905 and 1906 some 60 or 70 egg clusters were destroyed; during the past summer trees were burlaped, several acres of brush land cut over, some of the stone walls burned out, and the moth vigorously hunted by the State authorities under direction of Doctor Britton. Since the egg-laying season of the past summer about 40 more egg clusters were destroyed. Unless an examination of the surrounding territory should reveal the moth over a much larger area, this colony should be entirely stamped out within a year or two, although it will require careful watching for several seasons to be sure that it does not reestablish itself.

DESCRIPTION OF THE INSECT.

The eggs.—The eggs of the gipsy moth are laid in masses (fig. 2) of about five hundred. The individual egg is minute, about the size of a pinhead, and is salmon-colored when first laid, but turns dark in the course of a few weeks. Each egg mass is yellowish in appearance and seems covered with hair. It is somewhat oval, being one-half of an inch long and about three-fourths of an inch wide. During winter, from exposure to moisture in the atmosphere, it becomes dingy white in color.

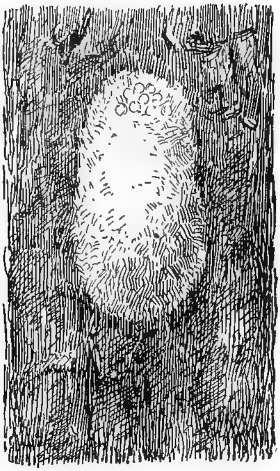

Fig. 2.—Egg mass of the gipsy moth (*Porthetria dispar*). (From Kirkland.)

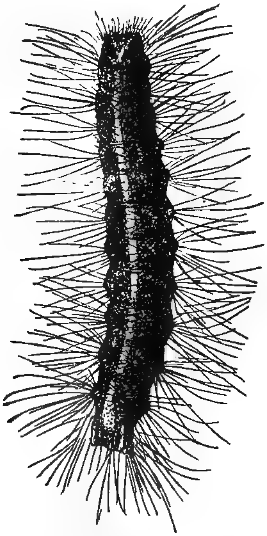

Fig. 3.—Full-grown caterpillar of the gipsy moth. Natural size (from Insect Life).

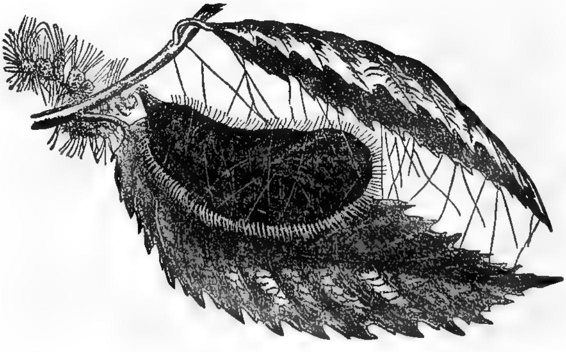

Fig. 4.—Pupa of gipsy moth. Natural size (from Insect Life).

The larva or caterpillar.—The young larvæ or young caterpillars are dark in color and well furnished with dark hairs. The full-grown larva (fig. 3) is between 2 and 3 inches long, dark brown or sooty in color, with two rows of red spots and two rows of blue spots along the back, and with a yellowish but rather dim stripe between them. The body generally is clothed with long hairs, and sometimes reaches the length of 3 inches.

The pupa.—The pupa (fig. 4) is not inclosed within a perfect cocoon, but the full-grown larva spins a few threads of silk as a sort of support and changes to the pupa, which is dark reddish or chocolate in color and very thinly sprinkled with light reddish hairs.

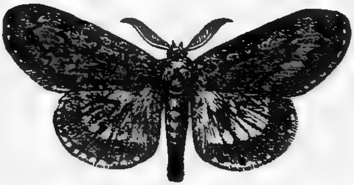

FIG. 5.—Male gipsy moth. Slightly enlarged (from Insect Life).

The adult or moth.—The male moth (fig. 5) is brownish yellow in color, sometimes having a greenish-brown tinge; it has a slender body, well-feathered antennæ, and a wing expanse of about an inch and a half. The forewings are marked with wavy zigzag darker lines. It flies actively all day as well as by night.

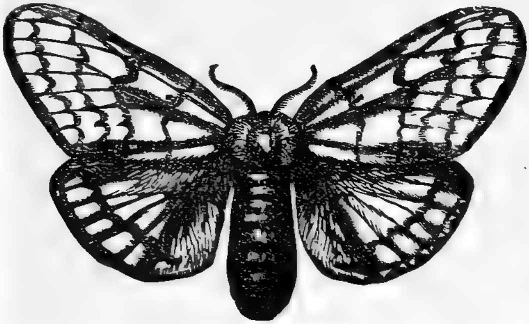

FIG. 6.—Female gipsy moth. Slightly enlarged (from Insect Life).

The female moth (fig. 6) is nearly white, with slender black antennæ, each of the forewings marked with three or four zigzag, transverse, dark lines, and the outer border of both pairs of wings with a series of black dots. The body of the female is so heavy as to prevent flight.

SEASONAL HISTORY.

The moths emerge from the pupæ from the middle of July to the middle of August, the date varying considerably according to the season. After mating they live but a short time, and the female dies after depositing her eggs.

The eggs are laid therefore in July and August. They are deposited by the moths on the trunks of the trees upon which the caterpillars have lived, and in fact usually in the vicinity of the place where the female has transformed. The caterpillars before transforming frequently crawl for some distance from the trees upon which they have been feeding, and it therefore happens that the egg masses will be found on fences and in all sorts of protected situations in which the caterpillars hide during the day. The crevices in stone fences often contain very many of these egg masses, and knot holes in old trees will also contain many which would not at first be discovered. The egg masses are found also in hollow trees, in crevices under rough bark, on shrubbery, on buildings, in wood piles, in barrels, in boxes, and among rubbish in dooryards. The moths seem to choose the inner or lower surface of an object upon which to lay their eggs, and therefore egg masses are placed out of sight perhaps as often as in sight.

The eggs hatch about May 1, and the young caterpillars begin immediately to feed, usually upon the lower surfaces of the leaves. As they grow they cast their skins several times, and as they become larger they feed only at night, hiding during the daytime, usually in clusters on the shady side of tree trunks, beneath large limbs, in holes in trees, under loose bark, and in fact under any nearby shelter. It is the habit of most of them to descend before daybreak upon the trunks of the trees and to seek for such shelters as those just indicated, returning after nightfall to resume their nocturnal feeding.

The larvæ usually become full grown about the 1st of July, and then transform to pupæ. The pupæ are found in the same situations as those we described for the egg clusters, but are found also in the foliage of trees and shrubs.

HOW THE INSECT SPREADS.

As indicated above, the bodies of the females are so heavy as to prevent flight. Therefore the insect must be principally distributed while in the caterpillar or larval condition. The caterpillars are active crawlers, but as a rule do not migrate from the localities where they were born except when food is scarce. When young, and when there is hardly enough food, the larvæ spin down from trees by means of silken threads and often alight upon vehicles of one kind or another, and are thus carried often for great distances from the place of birth. Trolley cars, carriages, automobiles, and bicycles are thus means of transportation almost unlimited in their possibilities. The caterpillars often crawl upon vehicles which happen to stand for any length of time in an infested locality, and thus may be carried great distances. Sometimes even pedestrians aid unwittingly in this distribution, since the caterpillars may drop by their threads upon the garments of a person passing under an infested tree.

The species may be transported, too, in the egg stage. It has been shown that the egg clusters are laid upon many different kinds of objects. Cord wood stacked and piled may be carried away in the autumn bearing many egg masses, and, if not burned before summer, larvæ may issue in a new locality. The same may be said for lumber piles near infested trees. Freight cars may have been sidetracked near an infested place long enough to permit laying of the eggs upon them.

It is by these methods that the comparatively rapid spread of the insect previously noticed, during the years 1900–1905, is to be explained.

DAMAGE TO PLANTS.

The larva of the gipsy moth feeds upon the foliage of practically all orchard trees, all shade and ornamental trees, all out-of-door shrubs, and all forest trees. Not only are the deciduous forest trees stripped, but the coniferous trees as well. In June and July patches of forests in the infested territory are stripped of every green leaf and the trees appear as bare as in winter. After several such consecutive strippings, deciduous forest and shade trees are killed, but with a coniferous tree, such as a pine, hemlock, or spruce, one complete stripping will cause death. It is this fact which makes the gipsy moth so much more serious a pest than the brown-tail moth, and the loss which will result from its spread into northern New England will be very great, owing to the enormous coniferous forest interests in that part of the country.

In cities and towns the insect does damage not only by destroying all vegetation, but by swarming in numbers upon and about houses, frequently entering them. It has been the experience in eastern Massachusetts that where a locality becomes thoroughly infested the value of real estate rapidly depreciates, and it becomes a matter of difficulty to rent or sell property.

Among its food plants the gipsy moth caterpillar seems to prefer apple, white oak, red oak, willow, and elm, but those who have studied it most carefully in Massachusetts say that it will on occasion devour almost every useful grass, plant, flower, shrub, vine, bush, garden, or field crop that grows in the State.

NATURAL ENEMIES AND PARASITES.

Observations extending over a number of years show that birds have some importance as enemies of the gipsy moth. As already suggested, the fact that the insects spread comparatively slowly in the vicinity of Medford between the years 1869 and 1889 is probably to be accounted for in part by the fact that insectivorous birds were much more numerous in that part of Massachusetts during that period than they have been since. Not only have the English sparrows (which, by the way, feed but rarely upon the gipsy moth) driven away many of the other birds, but pot-hunters from Boston and from the manufacturing towns about Boston, especially persons of foreign birth, have destroyed great numbers of insectivorous birds. The caterpillars are preyed upon by the cuckoos, the Baltimore oriole, the yellow-throated vireo, and the blue jay. The moths, when they emerge, are eaten by many birds, and the eggs are eaten by several species.

Certain of our native parasites which destroy allied insects like the fall webworm and the tussock moth also breed in the gipsy moth caterpillar and chrysalis. A number of species were bred during the early Massachusetts State work, but the percentage of parasitism was very small.

An effort is being made by the Bureau of Entomology, in cooperation with the Massachusetts State authorities, to introduce the European parasites of the gipsy moth, and of the brown-tail moth as well, and during the past year many thousands of such parasites have been introduced and liberated in the vicinity of Boston. They are first cared for in a laboratory at North Saugus; many of them are afterwards studied under out-of-door tents, while still others have been liberated in the open and badly infested woodlands, such locations for liberation having been chosen as are likely to remain undisturbed either by insecticidal operations or by forest fires. The results so far are encouraging, but it may be, and probably will be, several years before appreciable results will be obtained, and it may be that these European parasites will not increase as rapidly or do as good work as they are known to do in Europe. In the Old World, as has been previously indicated, the gipsy moth is only occasionally present in sufficient numbers to do noteworthy damage, and it is ordinarily kept in check by its parasites and other natural enemies. In this country, therefore, active mechanical measures must still be continued, and perhaps for years to come, in the actual destruction of the injurious insect before relief from parasites is gained.

REMEDIES.

The gipsy moth, when occurring in moderate numbers, is not at all a difficult insect to fight. When young the caterpillars are readily killed by spraying the trees with the ordinary arsenical poisons. As they grow older they develop a remarkable resistance to the action of arsenic, so that stronger and stronger proportions must be used. It was early found that Paris green and London purple can not be used effectively against well-grown larvæ unless the proportion of the arsenical to the amount of water is so great as to burn the foliage of the trees or plants. Therefore the substance known as arsenate of lead, which admits of much stronger proportions without damage to foliage, was introduced and has since been extensively used, not only against the well-grown gipsy moth larvæ, but against other leaf-eating insects.

But against the larger larvæ other measures may be used to advantage. It has been pointed out that it is the habit of the larvæ to descend upon the trunk of the tree in the early morning and to hide under any protection until nightfall. Therefore, if a strip of burlap or other coarse, cheap cloth is tied about an infested tree trunk by the middle, in such a manner that the flaps hang down (see fig. 7), the caterpillars, as soon as they have reached this stage, will gather for the day under the cloth and can be destroyed by crushing or cutting. The burlap should be examined daily, and may be employed from the latter half of May to the first or middle of August—as late as the latter date, for the reason that many caterpillars transform to pupæ under the burlap and many egg masses are also laid under it. As Kirkland has well expressed it, "It should be borne in mind that the cloth band is in no sense a tree protector; nor is it a trap. Its function is simply to give the shelter which the caterpillars seek by day. Serving as it does as a hiding place for various insects, it is better off the tree than on unless it can be attended to and kept clean. At the end of the caterpillar season all burlaps should be removed and burned. To insure best results on high trees, such as street elms, burlaps should be placed around some of the larger limbs, as well as around the trunk, as many caterpillars will seek shelter up in the tree rather than descend to the ground. The most effective results in using the burlap are obtained where cavities, crevices, etc., in the trees have been first filled with cement or covered with zinc and all loose bark removed. If these hiding places are destroyed nearly all the caterpillars will seek the burlap at some time during the season."

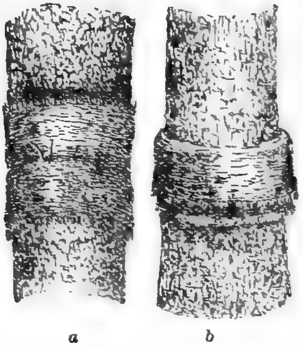

FIG. 7.—Manner of applying burlap bands: *a*, band as originally tied; *b*, band with upper half turned down. Greatly reduced (after Forbush).

One of the most effective methods of destruction consists in killing the eggs. The egg masses are often conspicuous and accessible and may be destroyed by applying creosote mixtures by a small swab or paint brush. This mixture may be bought at agricultural warehouses and seed stores at from 50 cents to $1 a gallon. Every egg mass thus treated means the destruction of 500 potential caterpillars. The egg clusters should be creosoted early in the autumn if possible, since they are likely to be broken and the eggs scattered on the ground by the rubbing of animals against the trees, or by the breaking open of the clusters by cats and squirrels, or by the picking of birds, thus also scattering the eggs. Much good can also be accomplished by burning over unimproved tracts of brush land and burning out the undergrowth in sparse woodlands. Where the clusters are very plentiful, burning the ground over with oil to destroy eggs scattered as the result of the cutting of trees and bushes will, according to Kirkland, be required to insure thorough work. The burning method is also effective in May or June, after the young larvæ have hatched.

With the creosoting of the eggs, the spraying against the young larvæ, the burlaping against the old larvæ, and with burning in places indicated, the insect may be kept in check. So great, however, is the prolificacy of the species, and in such enormous numbers does it occur in eastern Massachusetts, that the thorough use of these and other methods of destruction upon a large estate involves a great expenditure of money. For example, Gen. S. C. Lawrence for a number of years kept a large force of men working upon certain gipsy moth colonies in his own and adjoining forest lands, and expended each year more than the actual value of the lands. This experience, however, need not and should not discourage small property holders from vigorous efforts to destroy the insects upon their own holdings. Unless extraordinarily abundant, it is perfectly feasible to hold them in check.

One of the most serious features of the damage is the injury in park lands in eastern Massachusetts, where thousands of acres are infested and where important problems exist. From long experience the best methods for treating these wooded sections have been proven to be the cutting out and burning of all underbrush, the removal of trees which have died or have inaccessible cavities in them, and the burning of all refuse on the ground. It is almost impossible to inspect the thick growths of underbrush for the various stages of the moth, and there is no method for their treatment at a reasonable cost. Trees which have been scarred by forest fires, or from other causes, often have cavities in them which provide admirable hiding places for these insects, and should be removed to prevent the constant expense of inspection.

Apple orchards, also, aside from those receiving the most careful attention, offer favorable breeding places for the moth. There are in New England thousands of old, badly infested apple trees which have passed their usefulness for producing good fruit, and the ground which they occupy might better be devoted to other crops or to newly set orchards. The field force rarely goes into an orchard that has not several trees with holes in them which might harbor the gipsy moth so safely that its presence could not be detected unless the tree were cut open. Such trees, if not worth being cared for by cementing or tinning the holes to prevent the entrance and exit of the gipsy moth, should be cut and burned.

Hedges of brush along roadsides and stone walls also offer favorable breeding and hiding places for the pest. In such places the presence of the moth may not be discovered for several years, the caterpillars feeding upon the brush and nesting in stone walls until the colony has developed to sufficient size to attract attention by its depredations on neighboring trees, upon which its presence is easily discovered. The cutting and burning of these rows of worthless shrubbery each year until killed not only removes a favorite hiding place for various insect pests, but also gives the roadside and farm a much more trim appearance.

WHAT THE STATE OF MASSACHUSETTS IS DOING FOR THE CONTROL OF THE INSECT.

In the session of the Massachusetts legislature in the spring of 1905 a law was passed which had for its object the suppression of the gipsy and brown tail moths. The essential features of this law are as follows:

FEATURES OF THE MASSACHUSETTS LAW.

The moths are public nuisances.—The gipsy and brown tail moths are declared public nuisances and their suppression is required.

The superintendent of suppression.—A superintendent appointed by the governor with power, subject to the governor's approval, of appointing agents and assistants has entire general charge of the work of suppressing the moths.

Duties of cities, towns, and individuals.—Cities and towns (under the advice and general direction of the superintendent, and by such agent as they may designate or appoint) are required, under penalty for neglect, to destroy the eggs, pupæ, and nests of the gipsy and the brown-tail moths within their limits, *excepting* that such work is not to be done by cities and towns on property controlled by the Commonwealth, nor is it to be done upon private property, excepting where the owners of the same fail to destroy the eggs, pupæ, and nests of the moths, in accordance with the terms of the official notice to private owners noted in the section here following:

Notice to private owners.—The mayor of every city and the selectmen of every town shall, at suitable times, notify every owner of land located therein which is infested with the moths, requiring him to destroy the eggs, pupæ, and nests of the moths within a specified time.

When the mayor or selectmen decide that the cost of such destruction (on lands contiguous and under one ownership) will exceed one-half of 1 per cent of the assessed valuation of the lands, then they may designate in the notice a part only of such lands on which the destruction shall take place.

Failure of private owners to destroy moths.—If the owner does not, as required by the terms of the aforesaid notice, destroy the eggs, pupæ, and nests of the moths, then the city or town, subject to the approval of the State superintendent, shall destroy them, and shall assess upon such aforesaid lands the actual cost of so doing, to an amount, however, not exceeding one-half of 1 per cent of the assessed valuation of the land.

This amount, so assessed, shall be collected in the form of taxes, and constitutes a lien upon such lands.

Redress by abatement and appeal.—The assessors may abate the moth assessment in the case of any private landowner decided by them to be unable to pay it because of age, infirmity, or poverty.

Appeal to the county superior court, with special provision for prompt hearing, is provided by the statute for any person aggrieved by assessment on account of this work; provided a complaint is entered within 30 days of notice of such assessment.

Appropriation by the Commonwealth.—To meet the expenses incurred under its moth-suppression law the Commonwealth has appropriated $300,000. Of this sum $75,000 may be expended during 1905, $150,000 (and any unexpended balance) during 1906, and $75,000 (and any unexpended balance) during 1907, up to May 1, 1907, inclusive.

For the purpose of experimenting with natural enemies for destroying the moths, $10,000 is additionally appropriated for each of the years 1905, 1906, and 1907.

Reimbursements to cities and towns.—(1) Cities and towns with valuation of real and personal estate of $12,500,000 or more, having spent $5,000 in any one calendar year, shall be reimbursed annually 50 per cent (one-half) of all further expenditure in combating this pest.

(2) Cities and towns with valuation less than $12,500,000 and more than $6,000,000, having spent an amount equal to one twenty-fifth of 1 per cent of such valuation in one year, shall be reimbursed annually 80 per cent (four-fifths) of all further expenditure.

(3) Towns with valuation less than $6,000,000, having spent an amount equal to one twenty-fifth of 1 per cent of such valuation in one year, shall be reimbursed once in 60 days for all further expenditure.

Limits to required expenditure by cities and towns.—No city or town with an assessed real and personal valuation of more than $6,000,000 shall be required to expend in the suppression of the moths during any one full year more than one-fifteenth of 1 per cent of such valuation. No town with an assessed real and personal valuation of less than $6,000,000 shall be required to thus expend during any one full year more than one twenty-fifth of 1 per cent of such valuation.

Valuations of 1904 taken as basis.—Wherever valuations of real and personal property are referred to in the law for the suppression of the gipsy and brown-tail moth the valuations of 1904 are meant.

Willful resistance or obstruction.—Willful resistance to or obstruction of any agent of the Commonwealth or of any city or town, while lawfully engaged in the execution of the purposes of the moth-suppression law, is forbidden under penalty.

Under this law, Mr. A. H. Kirkland, a very well equipped man, was appointed superintendent, organized an effective force, and during the seasons of 1905 and 1906 has done excellent work. The experiences of these two years have shown certain defects in the law, which it is hoped will be remedied at the coming session of the State legislature.

WHAT OTHER STATES HOPE TO DO.

The comparatively recent spread of the gipsy moth into the States of New Hampshire, Connecticut, Rhode Island, and Maine, as indicated in an earlier paragraph of this bulletin, has created great public interest in these States, and at the coming sessions of the legislatures efforts will be made in each State to secure the passage of a law based upon the Massachusetts State law summarized above. In the meantime the State of Rhode Island has expended a certain amount of money appropriated by the legislature last winter, and the State of Connecticut has used certain funds at the disposal of the Director of the State agricultural experiment station. In New Hampshire and Maine no State work has yet been done.

WHAT THE NATIONAL GOVERNMENT IS DOING.

Congress at its last session appropriated, as elsewhere stated, the sum of $82,500 to be expended in an effort to prevent the further spread of the gipsy moth and the brown-tail moth. This money became available July 1, 1906, so that it was impossible to perfect the organization of the work in time to attempt any extended measures against the caterpillars this season. Mr. D. M. Rogers, formerly Mr. Kirkland's first assistant, was appointed special agent of the Bureau of Entomology in charge of the field work, a force of inspectors and laborers was organized, and work was begun about the middle of July.

After looking over the whole field and discussing the question at length with Messrs. Kirkland and Rogers, the writer concluded that since it seems obvious that nearly all of the recent spread of the gipsy moth has taken place by means of vehicles coming from the interior of the most thickly infested regions, the most effective manner of preventing further extensive spread would be to clean up the main traveled roads in the most thickly infested portions of the old gipsy-moth territory. The main work, therefore, was begun in the State of Massachusetts, and forces of men were placed on the principal infested roads to clean the shade trees and the underbrush for some distance back from the roads, in order that there may be no opportunity the coming season for caterpillars to spin down upon vehicles or passers-by, and thus to be carried to distances.

By cooperation with the State authorities in Rhode Island and Connecticut an effort has been made to stamp out the isolated colonies in these two States. This work has been actively carried on throughout the year, the Bureau paying for the services of the laborers and controlling their work in Rhode Island, but in the Connecticut case leaving affairs in charge of the State authorities.

Scouting parties have been and are working in New Hampshire and Maine in the effort accurately to map every infested point in order that all isolated colonies may be destroyed.

All of this work will be continued until the close of the fiscal year, and afterward provided Congress shall renew the appropriation.

The Government field office for gipsy-moth work is at No. 6 Beacon street, Boston, Mass., and the special field agent in charge is Mr. D. M. Rogers.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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Public Document **No.**

FOURTH ANNUAL REPORT

OF THE

SUPERINTENDENT

FOR

SUPPRESSING THE GYPSY AND BROWN-TAIL MOTHS.

JANUARY, 1909.

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The Commonwealth of Massachusetts.

To the Senate and House of Representatives of the Commonwealth of Massachusetts.

I present herewith for your consideration the fourth report on the work of suppressing the gypsy and brown-tail moths. Owing to the resignation of Superintendent A. H. Kirkland, on Dec. 1, 1908, which was deeply regretted by this office, the duty of submitting this report devolves upon me, as acting superintendent. This report is submitted in accordance with the provisions of chapter 381, Acts of 1905, and contains a statement of the results obtained during the year 1908, together with a record of expenditures and certain recommendations concerning the future needs of the work.

L. H. WORTHLEY,
Acting Superintendent.

JAN. 1, 1909.

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Charles O. Bailey,	*Secretary.*
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The Commonwealth of Massachusetts.

THE GYPSY AND BROWN-TAIL MOTHS.

The year 1908, from the entomological standpoint, has been a notable one in Massachusetts, for two reasons: first, the general severity of insect damage of all kinds; and second, the rapidity with which such damage developed. While the canker worm, tussock moth, elm-leaf beetle and a host of other insect pests were unusually abundant, no better illustration of the effect of abnormal climatic conditions on insect life can be found than was shown by the gypsy moth and the brown-tail moth during the past year. The winter was favorable to the successful hibernation of these insects. The spring opened early, and the warm, dry season, almost entirely free from rain, gave caterpillars nearly ideal conditions for their rapid development. At the same time, these conditions seemed decidedly adverse to the increase of certain fungous and bacterial diseases which have in recent years been of great assistance in killing off the caterpillars. At any rate, we did not receive the usual amount of help from these natural aids. These conditions brought about an early development and rapid increase of damage by the gypsy moth caterpillars in sections where it had not been possible to cover the territory thoroughly in treating the egg clusters, more particularly in woodlands, where nothing had been done but thinning preliminary to wholesale spraying operations. It is needless to say that all the resources of the department, as well as those of each badly infested city or town, were severely taxed in order to prevent widespread damage. We feel it to be greatly to the credit of the city and town organizations that they were able in nearly all cases to meet this emergency by well-planned spraying operations, and to destroy the caterpillars in their early stages of growth. Their principal devastation was therefore confined to woodlands of low valuation, and the highway trees throughout the district and those on residential and farming property were protected. It is not probable that such another year will occur for some time; but the experience of the past summer showed plainly the importance of equipping each city and town with spraying outfits, adequate in number and power to deal thoroughly with such an emergency should it again arise.

During the year 1908 the fight against the gypsy and brown-tail moths has been carried on practically along the same lines as in the three preceding years, and with equally gratifying results. In the early part of the year it seemed important that the scouting operations which were begun in the fall of 1907 should be continued, so that we might determine more exactly the extent of the gypsy moth infestation in Massachusetts. This work was continued until April, about 100 trained men being thus employed. In several of the towns along the border of the previously known infested district a number of small colonies were located. During the summer months these colonies were given careful attention, since their complete extermination seemed entirely practicable. That this policy was a wise one has been proved by the results of the summer and fall work. In many of these small colonies no caterpillars were found, while in several others no egg clusters were found at the time of the fall inspection.

The residential sections in the badly infested central towns are in very good condition at this writing, and in nearly all of the cities and towns most excellent work has been done. We now have a large, well-trained force of men throughout the entire district, sufficient to enable us to conduct the work much more economically than has ever been possible before. As long as it was necessary to train and educate men in the details of the moth work in any given town, that work was necessarily very expensive. There are to-day in each city and town a considerable number of men who have had the benefit of this training and experience, and whose services can usually be obtained when needed.

The recommendations made in the last annual report were in the main adopted by the General Court, and have been most helpful to the work of the department. There have been but few cities and towns where the necessary appropriations have not been made promptly, thus relieving this office of the duty of enforcing the provisions of the law. As far as has been ascertained, very little dissatisfaction from citizens has been experienced by city and town officials in carrying out the requirements of the law. The balance of approximately $75,000, shown in the financial statement of Dec. 1, 1907, was used in part in reimbursements to cities and towns for the work of that year, and a portion carried forward to the 1908 account. This small balance, together with appropriations of $300,000 for 1908, have been nearly all expended in this year's work.

The greatly improved conditions in the residential districts have permitted us to take up the work in woodlands on a larger scale than ever before, and thousands of acres of woodland have been protected from the ravages of the moths. In some cases this work has involved the thinning and spraying of trees over large areas. In other cases it has been necessary to inspect thousands of acres, locating the incipient colonies and then stamping them out; but we have made a substantial and as we believe a satisfactory beginning on the great woodland problem, which, after all, is the most serious feature of the gypsy moth infestation in Massachusetts. In several cities and towns where serious woodland infestations exist the citizens have awakened to the danger threatening their forests, and to the fact that the Commonwealth cannot in justice to the other towns in the district reimburse them its proportional part of the cost of the work necessary to be done to protect them from the gypsy moth. These towns and cities have in a most commendable spirit made additional appropriations from the municipal treasuries sufficient to provide for the necessary year's work. Notable examples of this are found at Weston and Lincoln, where several thousand dollars in excess of allotments from the central office have been spent. This generous policy has naturally encouraged the department to deal liberally with such towns, since it has been our constant policy from the beginning of the work to give the greatest measure of help to those who showed the greatest desire to help themselves.

The largest number of men engaged in the work at any time during the year was slightly over 2,400, — a larger force than has ever been similarly employed. There has been manifest on the part of property owners in general a commendable spirit of co-operation, particularly in the districts where the brown-tail moth was the principal insect to be combated. As might be expected, in sections where the insects have been reduced in numbers so that the damage by them is no longer noticeable, a certain degree of apathy on the part of property owners is beginning to be apparent. This is a repetition of the condition of affairs a decade ago. It is the present danger which we fear, — not the one through which we have safely passed. We believe that this attitude is an entirely wrong one, since it should be borne in mind that even a few gypsy moth egg clusters or a few brown-tail moth webs, if neglected, will within a few years increase to such numbers as to become a very present danger.

With the approval of the Governor, this office has contributed $20,000 to a fund of $50,000 which has been used in suppressing the gypsy moths in the north shore woods, in an effort to treat in its entirety this valuable section of woodland. The balance of the fund, $30,000, has been raised through the energetic efforts of Col. William D. Sohier. A detailed account of the expenditure of this fund and the work accomplished will be found later in this report.

The work of importing and propagating parasites during the year 1908 has been prosecuted as vigorously as heretofore, with even better results, both in the laboratory and in the field. By the aid of the experts kindly furnished by the Bureau of Entomology, United States Department of Agriculture, working under the direction of Dr. L. O. Howard, many difficult and important problems in the life histories of these valuable insect allies have been worked out, and with certain species the method of their easy and rapid multiplication has been greatly simplified. Large numbers of the parasites of both the gypsy moth and the brown-tail moth have been liberated in various suitable localities, and are known to have become established, although, as might be expected, no practical results on a large scale have been perceived as yet.

SYNOPSIS OF THE REPORT.

1. In spite of the unusual climatic conditions favoring the increase of the gypsy and brown-tail moths in 1908, the local organizations as a rule have shown themselves able to keep the insects under control except in the woodland districts, where lack of funds do not permit extensive operations.

2. The policy of cleaning the trees along the streets and highways and in residential and farming sections has been continued, with satisfactory results.

3. A special effort has been made to protect the north shore woodlands through a co-operative plan of work, the greater portion of the funds for these operations being provided by the interested citizens and municipalities.

4. A satisfactory spirit of co-operation has been shown by city and town officials as a whole, and by citizens of the infested district.

5. Greater progress has been made in the importation and rearing of parasites of the gypsy and brown-tail moths during 1908 than in any single year heretofore.

Recommendations are: —

1. To continue the field work at its maximum efficiency, an appropriation of $150,000, in addition to that already provided for the year 1909, should be made.

2. To continue the work of importation of parasites and for work on fungous and bacterial diseases an appropriation of $15,000, in addition to any unexpended balance, should be made.

3. To provide for the uninterrupted continuation of the work against the gypsy and brown-tail moths, that the work may not suffer from legislative delays in the winter and spring, when most effective work can be done, a suitable appropriation should be made for a period of at least three years.

FINANCIAL STATEMENT.

As explained in previous reports, although the law requires the superintendent to "separate, as far as practicable, the expenditures on work against the gypsy moth from those on work against the brown-tail moth," this is an impossible requirement. The winter work against both the brown-tail moth and the gypsy moth is done by the same gang of men and at the same time. When a man goes into a tree, he clears it of both brown-tail moth webs and gypsy moth egg clusters, and to make such a separation as required would involve an endless amount of bookkeeping, as well as an enormous expense.

As far as possible, we have obtained complete returns from all cities and towns showing their expenditures in the work against the gypsy and brown-tail moths up to the close of the fiscal year, Nov. 30, 1908. There are, as usual, a certain number of dilatory municipalities whose accounts are not yet made up, while in other cases certain items of expense which appear to be open to question are held pending adjustment. As previously mentioned, the balance carried forward from Nov. 30, 1907, $75,734.83, was largely paid out in reimbursement to towns which had failed to make returns at the time of closing the books. For the same reason, the balance of $1,223.37 on hand Nov. 30, 1908, is apparent rather than real, and will doubtless be disbursed during the current month.

General appropriation: —		
Balance from 1907,	$75,734 83	
Appropriation for 1908,	150,000 00	
Appropriation of June 8, 1908,	150,000 00	
Credit for cash returned,	10 85	
		$375,745 68
Office expenses: —		
Management,	$5,000 00	
Salaries of clerks,	2,402 00	
Rent,	1,440 00	
Stationery and postage,	1,137 09	
Printing,	949 42	
Experts,	248 15	
Supplies and furniture,	131 88	
Sundries,	1,182 44	
Educational work,	40 75	
Field expenses: —		
Wages of employees,	72,057 06	
Travelling expenses of employees,	13,470 00	
Supplies,	583 22	
Amounts carried forward,	$98,642 01	$375,745 68

Amounts brought forward,	$98,642 01	$375,745 68
Special work in parks, etc.,	[1]23,713 71	
Supplies for experiments,	98 05	
Emergency work,	228 00	
Reimbursements to cities and towns,	251,703 17	
Sundries,	137 37	
		374,522 31
Balance Nov. 30, 1908,		$1,223 37

PARASITE APPROPRIATION.

We have endeavored to handle the appropriation for this part of our work economically, and yet at the same time have not hesitated to make relatively large expenditures where the probability of securing desirable results seemed to warrant them. The one large item of expense in this connection was a trip to Japan, made by Prof. Trevor Kincaid in search of parasites of the Japanese gypsy moth. The results of his trip have amply justified the outlay, and we have obtained from Japan parasites which we believe will prove to be of enormous value in destroying the egg clusters of the gypsy moth. The total expenses incurred in this work during the year 1908 are given below: —

Balance from 1907,	$10,325 88	
Appropriation of June 8, 1908,	25,000 00	
		$35,325 88
Expenditures: —		
Wages of employees,	$5,804 39	
Travelling expenses of employees,	2,120 06	
Rent,	505 00	
Supplies,	1,964 17	
Stationery and postage,	47 98	
Printing,	65 39	
Experts,	91 57	
Sundries,	588 73	
Importation of parasites,	5,208 50	
		16,395 79
Balance Nov. 30, 1908,		$18,930 09

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[1] This amount includes $20,000 contributed by this department to special north shore fund. For expenditures under this fund, see page 48.

Analysis of Town Expenses.

The only item in the subjoined analysis of town expenses requiring any particular explanation is the relatively large outlay for supplies. A large item in this class of expenses is caused by the purchase of power spraying outfits. In the years during which this department has directed the work against the moths a great deal of preliminary work, such as thinning of trees, cutting of brush, removal of decayed trees, etc., has been done. A very large part of the territory is now in condition to be treated mainly by spraying, which is the most economical single method of fighting the moths. Furthermore, we are now taking up generally throughout the district the suppression of the moths in woodlands, — work which can best be done by spraying; hence it has seemed desirable to have the cities and towns as far as funds would permit equip themselves with large power sprayers, to the end that their future operations may be carried on more economically and more effectively. The total amount spent in 94 towns and cities, receiving reimbursement from the State to the amount of $247,733.84, may be distributed as follows: —

Total amount spent,	$521,753 31	
Private work deducted,	91,183 53	
		$430,569 78
Pay roll,	$336,751 91	
Teaming,	16,373 38	
Travel,	1,204 45	
Rent,	646 25	
Supplies,	70,882 25	
Sundries,	2,993 89	
Stationery and postage,	921 71	
Printing,	795 94	
		$430,569 78

Financial Summary by Towns.

The following table shows the expenditures required of cities and towns before receiving reimbursement from the State, and the total net expenditure and reimbursement of each city and town in the infested gypsy moth district for 1907 and 1908.

The columns for 1907 include all reimbursements on account of work done during that year, some of which had not been made at the time the report for 1907 went to press.

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Reimbursement.	Required Expenditure.	Total Expenditure.	Reimbursement.
Abington,	$1,043 29	–		$1,112 52	$2,605 96	$1,493 44
Acton,	702 95	$2,960 67	$2,257 82	719 42	3,205 23	2,485 81
Amesbury,	2,092 90	1,086 52		2,331 90	2,710 00	378 10
Andover,	2,410 05	3,685 76	1,020 57	2,485 53	5,441 99	2,365 17
Arlington,	4,046 34	11,450 02	5,993 94	4,355 02	11,991 38	6,109 09
Ashby,	–	–		202 69	98 36	–
Ashland,	414 44	740 59	326 15	437 73	778 97	341 24
Attleborough,	–	–		5,000 00	306 40	–
Avon,	363 40			382 54	105 21	–
Ayer,	717 22	–		803 29	–	–
Auburn,	–			429 40	–	–
Barnstable,	2,002 04			2,162 12	–	–
Bedford,	492 97	6,533 22	6,040 25	514 05	9,980 77	9,466 72
Bellingham,	–	–		325 77	37 23	–
Belmont,	2,249 64	5,411 51	3,161 87	2,397 97	2,970 90	572 93
Berlin,	216 08	280 95	64 87	218 75	679 58	460 83
Beverly,	5,000 00	8,244 88	1,622 45	5,000 00	8,779 19	1,889 61
Billerica,	878 28	4,189 78	3,311 50	898 36	6,989 45	6,091 09
Bolton,	195 16	417 54	222 38	196 49	607 56	411 07
Boston,	5,000 00	10,909 76	–	5,000 00	10,481 43	
Bourne,	1,081 86	–		1,333 71	2,822 72	1,489 01
Boxborough,	97 09	1,013 37	916 28	100 85	1,906 38	1,805 43
Boxford,	438 84	1,800 75	1,361 91	471 26	2,537 61	2,066 35
Braintree,	1,989 47	–	–	2,256 42	3,801 69	
Bridgewater,	1,257 56	–	–	1,298 95	860 27	
Brockton,	5,000 00			5,000 00	500 00	
Brookline,	5,000 00		–	5,000 00	–	–
Burlington,	232 50	4,068 44	3,835 94	243 93	5,843 37	5,599 44
Cambridge,	5,000 00	3,260 99 983 56	380 50 –	5,000 00	4,881 03	–
Canton,	1,541 40	–	–	1,577 67	402 00	–
Carlisle,	164 96	3,276 29	3,111 33	166 48	5,652 06	5,485 58
Carver,	549 31	645 78	96 47	527 74	4,169 01	3,641 27
Chelmsford,	1,248 16	4,265 09	3,016 93	1,319 36	5,060 34	3,740 98
Chelsea,	5,000 00		–	5,000 00	1,455 90	–

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Reimbursement.	Required Expenditure.	Total Expenditure.	Reimbursement.
Clinton, . .	$3,211 14	–	–	$3,178 27	$1,817 24	–
Cohasset, . .	2,601 07	$2,883 59	$226 02	2,859 28	4,029 78	$936 40
Concord, . .	2,233 87	5,755 78	3,521 91	2,450 48	8,912 55	5,169 66
Danvers, . .	2,183 64	7,630 23	5,446 59	2,284 22	8,725 93	6,441 71
Dedham, . .	4,461 35			4,821 53	327 34	–
Dennis, . .	–	–		474 40	78 55	–
Dover, . .	393 63	2,030 42	1,636 79	470 45	1,958 01	1,487 56
Dracut, .	862 81	1,260 03	397 22	876 41	3,339 02	2,462 61
Dunstable, . .	116 03	814 43	698 40	118 04	662 71	544 67
Duxbury, . .	772 63	1,680 63	908 00	857 10	4,239 01	3,381 91
East Bridgewater,	664 79	1,417 46	752 67	693 46	4,639 24	3,945 78
Easton, . .	1,947 96	–	–	2,022 12	391 24	–
Essex, . .	422 27	2,198 84	1,776 57	430 86	2,527 08	2,096 22
Everett, . .	5,000 00	2,542 22	–	5,000 00	2,420 52	–
Falmouth. . .	3,128 51	–		3,167 28	674 56	
Fitchburg, . .	–			5,000 00	–	
Foxborough, .	–	–	–	882 40	34 25	–
Framingham, .	3,800 82	5,252 12	1,161 04	3,911 86	3,554 97	–
Franklin, . .	–	–	–	1,463 10	67 64	–
Gardner, .	–	–	–	2,798 77	–	–
Georgetown, .	394 98	1,033 92	638 94	403 76	1,555 43	1,151 67
Gloucester, .	5,000 00	6,506 28	753 14	5,000 00	9,127 08	2,063 54
Grafton, . .	–	–	–	1,068 13	365 33	–
Greenfield, . .	–	–	–	3,252 63		–
Groton, . .	1,205 98	–	–	1,199 52	736 34	–
Groveland, .	441 45	1,345 15	903 70	465 21	2,176 31	1,711 10
Halifax, . .	134 03	735 18	601 15	187 69	2,425 52	2,237 83
Hamilton, . .	1,186 10	3,432 79	2,246 69	1,378 11	4,545 74	3,167 63
Hanover, . .	551 55	1,938 89	1,387 34	569 46	4,624 06	4,054 60
Hanson, . .	366 28	796 46	430 18	501 40	2,372 79	1,871 39
Harvard, . .	437 53	139 32		520 36	1,136 97	616 61
Haverhill, . .	5,000 00	2,618 23	–	5,000 00	7,263 23	1,131 62
Hingham, . .	1,778 16	3,773 46	1,994 80	2,323 90	4,201 05	1,877 15
Holbrook, . .	511 06	215 76	–	547 06	247 00	–
Holden, . .		–	–	574 20	–	–
Holliston, . .	618 46	–	–	626 53	178 58	–
Hopkinton, .	649 77	816 60	166 83	623 27	1,433 43	810 16

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Reimbursement.	Required Expenditure.	Total Expenditure.	Reimbursement.
Hudson, . .	$1,276 38	$2,536 01	$1,259 63	$1,365 55	$2,365 14	$999 59
Hull, .	1,860 36	–		2,033 99	707 50	–
Hyde Park, .	5,000 00	–	–	5,000 00	2,836 09	–
Ipswich, . .	1,545 93	3,309 01	1,763 08	1,651 95	3,409 75	1,757 80
Kingston, . .	583 56	287 77	–	667 67	1,528 67	861 00
Lakeville, . .	252 84	–	–	265 24	–	–
Lawrence, .	5,000 00	–	–	5,000 00	–	
Leicester, . .	–	–	–	913 02	57 85	
Leominster, .	3,769 99	252 00	–	4,059 74	519 25	–
Lexington, . .	2,390 50	15,109 67	10,796 87	2,483 92	16,408 91	11,139 99
Lincoln, .	1,019 01	3,804 70	2,785 69	1,147 93	8,507 18	5,000 00
Littleton, . .	396 95	684 39	287 44	406 74	2,122 75	1,716 01
Lowell, . .	5,000 00	–	–	5,000 00	5,054 54	–
Lunenburg, .	400 47	–	–	410 74	492 08	81 34
Lynn, . .	2,500 00 5,000 00	6,400 58 12,695 42	3,900 58 3,847 72	5,000 00	6,168 53[1] 2,548 23	3,084 27 –
Lynnfield, . .	295 30	3,569 68	3,274 38	298 50	3,280 95	2,982 45
Malden, . .	5,000 00	10,367 13	2,683 57	5,000 00	3,971 90	–
Manchester, .	4,302 18	–	–	4,732 48	4,705 33	–
Marblehead, .	2,891 82	2,450 91	–	2,946 27	1,718 54	–
Marion, .	–	–	–	1,016 64	225 75	–
Marlborough, .	3,856 47	2,965 10 469 67	855 44 –	3,955 73	4,681 77	580 83
Marshfield, . .	673 59	842 96	170 37	752 57	3,141 82	2,389 25
Mashpee, . .	–	–		76 48	181 25	104 77
Maynard, .	1,426 30	2,498 36	1,072 06	1,492 94	3,044 22	1,551 28
Medfield, . .	613 01	–	–	618 44	166 54	–
Medford, . .	5,000 00	11,235 36	3,117 68	5,000 00	13,012 21	4,006 11
Medway, . .	–	–	–	538 74	137 74	–
Melrose, .	5,000 00	7,771 21	1,416 26	5,000 00	2,709 06	–
Merrimac, . .	495 08	684 48	189 40	491 33	2,089 35	1,598 02
Methuen, . .	2,073 56	3,844 35	1,770 79	2,236 41	5,570 41	3,334 00
Middleborough, .	1,696 37	–	–	1,764 24	1,810 64	–
Middleton, . .	276 30	1,867 74	1,591 44	303 19	2,147 61	1,844 42
Milford, . .	2,567 49	–	–	2,670 12	14 32	
Millbury, .	–		–	921 54	591 23	–
Millis, .	291 71	–	–	301 45	296 82	–
Milton, . .	5,000 00	–	–	5,000 00[2]	6,714 83	–
Nahant, . .	2,182 80	–	–	2,265 18	–	–

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[1] Lynn woods.

[2] No papers submitted.

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Reimbursement.	Required Expenditure.	Total Expenditure.	Reimbursement.
Natick, . .	$2,652 69	$6,313 48	$2,928 64	$2,740 16	$8,507 10	$4,613 56
Needham, . .	1,709 15	2,073 93	364 78	2,074 91	4,518 75	2,443 84
Newbury, . .	488 56	2,390 90	1,902 35	500 20	5,687 39	5,187 19
Newburyport, .	4,394 09	3,284 53	–	4,508 12	3,533 46	–
Newton, . .	5,000 00	6,522 72	761 36	5,000 00	10,451 33	2,730 67
Norfolk, . .			–	311 18	440 57	
North Andover, .	1,803 34	1,517 19	–	1,806 55	5,044 78	3,238 23
North Reading, .	267 68	2,183 49	1,915 81	269 25	3,026 51	2,757 26
Northbridge, .	–			1,595 69	–	–
Norwell, . .	332 95	840 36	507 41	349 23	2,640 80	2,291 57
Norwood, . .	2,153 65	–		2,404 95	–	–
Orleans, . .	236 63	–	–	244 08	96 30	
Oxford, . .	–	–	–	735 47	60 82	
Palmer, .	–	–	–	1,585 28	17 08	–
Peabody, . .	3,576 56	8,573 33	3,997 42	3,843 73	9,104 57	4,208 67
Pembroke, . .	374 78	483 23	108 45	380 34	1,490 06	1,109 72
Pepperell, . .	884 80		–	893 90	1,764 69	870 79
Plainville, . .	–			291 84	–	–
Plymouth, . .	3,829 92	–		4,095 44	–	–
Plympton, . .	131 09	791 16	660 07	130 71	5,635 58	5,504 87
Princeton, . .	–	–	–	413 75	40 50	
Quincy, . .	5,000 00	4,781 38	–	5,000 00	8,100 47	1,550 24
Randolph, . .	799 00	–	–	790 94	221 52	–
Raynham, . .	293 70	83 57	–	297 58	368 38	70 80
Reading, . .	1,886 39	7,846 05	5,959 66	1,996 61	8,970 91	6,974 30
Revere, . .	4,939 44	5,557 60	370 90	5,000 00	3,182 36	–
Rochester, .	–		–	249 56	345 90	96 34
Rockland, . .	1,363 81		–	1,403 65	2,078 82	675 17
Rockport, . .	1,227 31	2,070 11	842 80	1,232 16	2,032 50	800 34
Rowley, . .	295 72	988 17	692 45	299 19	1,346 92	1,047 73
Salem, . .	5,000 00	12,828 02	3,914 01	5,000 00	10,637 34	2,818 68
Salisbury, . .	332 53	2,141 61	1,809 08	331 91	2,435 82	2,103 91
Sandwich, . .	390 92	–	–	393 18	887 26	494 08
Saugus, . .	1,814 66	14,909 27	13,094 61	2,274 83	14,518 13	12,243 30
Scituate, . .	1,500 63	–	–	1.676 63	1,600 94	
Sharon, . .	–		–	1.015 19	178 82	
Sherborn, . .	441 09	1,240 14	799 05	538 11	2,001 93	1,463 82

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Re-imbursement.	Required Expenditure.	Total Expenditure.	Re-imbursement.
Shirley, . .	$378 12	–	–	$418 69	$241 08	–
Shrewsbury, .	–	–		584 13	198 43	–
Somerville, . .	5,000 00	$4,257 79		5,000 00	4,367 32	–
Southborough, .	587 06	2,083 01	$1,495 95	683 93	–	–
Springfield, .	–	–		5,000 00	56 38	–
Stoneham, . .	1,951 61	9,947 90	7,996 29	1,982 77	10,035 25	$8,052 48
Stoughton, . .	1,319 37	187 41	–	1,374 63		–
Stow, . .	332 73	798 20	465 47	352 45	1,126 25	773 80
Sudbury, . .	482 93	1,015 87	532 94	520 46	2,911 06	2,390 60
Sutton, .	–	–	–	484 95	69 94	
Swampscott, .	3,218 55	4,444 58	980 22	3,726 99	5,612 61	1,509 10
Taunton, . .	–	–	–	5,000 00	573 07	–
Tewksbury,. .	551 08	1,737 84	1,186 76	440 77	2,212 46	1,771 69
Topsfield, . .	397 69	2,426 19	2,028 50	429 63	2,154 89	1,725 26
Townsend, . .	–	–	–	456 95	112 52	
Truro, . .	–	–		149 78	–	
Tyngsborough, .	186 05	1,300 79	1,114 74	205 64	1,711 02	1,505 38
Upton, . .	–	–		430 25	237 28	–
Wakefield, . .	3,340 26	6,176 49	2,268 99	3,347 02	8,719 30	4,297 83
Walpole, . .	1,422 07	–	–	1,641 18	76 52	–
Waltham, . .	5,000 00	7,209 45	1,104 73	5,000 00	11,680 24	3,340 13
Wareham, . .	1,361 91	–	–	1,457 01	840 06	–
Warren, . .	–	–	–	739 22	58 35	–
Watertown, .	4,931 91	6,997 11	1,264 66	5,000 00	5,798 72	399 36
Wayland, . .	776 73	1,510 75	734 02	785 65	5,388 65	4,603 00
Webster, . .	–	–	–	2,564 02	–	
Wellesley, . .	4,721 43	3,188 79	–	5,000 00	6,174 84	587 42
Wellfleet, . .	–	–	–	413 25	50 33	
Wenham, . .	848 86	2,900 65	2,051 79	912 17	2,490 12	1,577 95
West Bridgewater,	448 07	1,086 72	638 65	475 50	1,817 67	1,342 17
West Newbury, .	414 60	1,573 12	1,158 52	423 73	7,739 93	7,316 20
Westborough, .	1,229 45	–	–	1,269 89	656 07	–
Westford, . .	649 21	2,350 70	1,701 49	670 12	3,397 53	2,727 41
Westminster, .	–	–	–	294 85	183 83	–
Weston, . .	2,231 64	5,169 97	2,938 33	2,365 77	18,861 30	10,541 99
Westwood, . .	833 40	–	–	863 64	424 14	–
Weymouth,. .	2,803 52	4,129 56	1,060 83	2,907 63	4,836 21	1,542 86

	1907.			1908.		
	Required Expenditure.	Total Expenditure.	Reimbursement.	Required Expenditure.	Total Expenditure.	Reimbursement.
Whitman, .	$1,639 90	–	–	$1,814 79	–	–
Wilmington, .	495 26	$2,393 20	$1,897 94	508 97	$4,312 48	$3,803 51
Winchester, .	4,202 25	10,526 11	5,059 09	4,404 26	5,414 36	808 08
Winthrop, . .	3,698 65			4,031 23	1,918 57	
Woburn, .	4,307 33	9,632 01	4,252 45	4,361 81	13,892 55	7,624 59
Worcester, .	5,000 00	–		5,000 00	398 66	
Wrentham, .	–	–		461 79	–	–
Yarmouth, . .	732 80	–	–	806 63	254 83	–

Allotments of Appropriations.

The distribution of our appropriation among the various infested cities and towns is a matter to which we have given considerable thought, in order that we may place the money where it will do the most good. It has always been the policy of this office to assist those who show a desire to help themselves, and we feel that this course of action should be continued. In some cities and towns, where the work has not been well done, we did not deem it advisable to make large allotments; on the other hand, where the work done was of a high quality, we felt that we should give assistance as far as our funds would permit.

The first allotment of expenditures for the year was made in the latter part of November, 1907, and at that time complete returns had not been received from all cities and towns; therefore, we were obliged to reserve all balance from 1907 for reimbursements. Later in the year we received a further appropriation from the Legislature, and additional allotments were made to cities and towns in need of money. The municipalities doing moth work the past season have in most cases realized their danger more than ever before, and have expended all the money allotted them. The coming season it will not be necessary to make any allotments from the appropriations for this office to several of the municipalities that have received reimbursement in the past, as their territory is in such a condition that the proper care of it in the future will not necessitate the expenditure of more than their liability. There are many places, however, where extensive woodland operations are necessary for protection, and here large amounts of money can be well used. The increased number of power spraying outfits in the field will have to be taken into consideration in making allotments for 1909.

Acknowledgments.

In previous years we have freely sought advice from those best qualified to give it, as the exigencies of the work demanded. It is impossible to mention the many good friends of the work in which we are engaged, who have helped by suggestion or counsel. We are particularly indebted, however, for helpful advice to the Honorable Attorney-General, the Honorable Auditor to the Commonwealth, the secretary of the Board of Agriculture, the officials of the Massachusetts Association for the Suppression of Gypsy and Brown-tail Moths, and also to Prof. C. H. Fernald, Col. W. D. Sohier and others. Finally, we are glad to acknowledge the loyal and efficient assistance given at all times by secretary C. O. Bailey, and field agents F. A. Bates, J. W. Enwright, J. A. Farley, C. W. Minott, Harry B. Ramsey and George A. Smith. Our thanks are also due to the officials of the various cities and towns, to the local moth superintendents and to the inspectors and other employees of the central office, for faithful service and hearty co-operation.

Scouting Work.

At the beginning of the year 1908 it seemed necessary to continue the scouting on as large a scale as during the fall of 1907, as the extent of the infestation by the gypsy moth had not been sufficiently well determined. In nearly all of the towns which had been scouted egg clusters of the gypsy moth were found, and it seemed necessary to continue until the border of the infestation was known. This work was continued until May 16, approximately 100 men being employed. The men engaged in this work were well trained and had a thorough knowledge of gypsy moth scouting, as the local officials in towns bordering on known infestations were not well enough acquainted with the habits of the gypsy moth to scout their own towns thoroughly. The results obtained by our scouting gangs were so satisfactory that we feel that the Commonwealth and the cities and towns thus scouted were both benefited by the work which was done. We have found it much easier to handle small infestations thus found than the larger colonies reported to this office by people who have been annoyed by the pest. In nearly all cases the infestations were located in orchards and decayed apple trees.

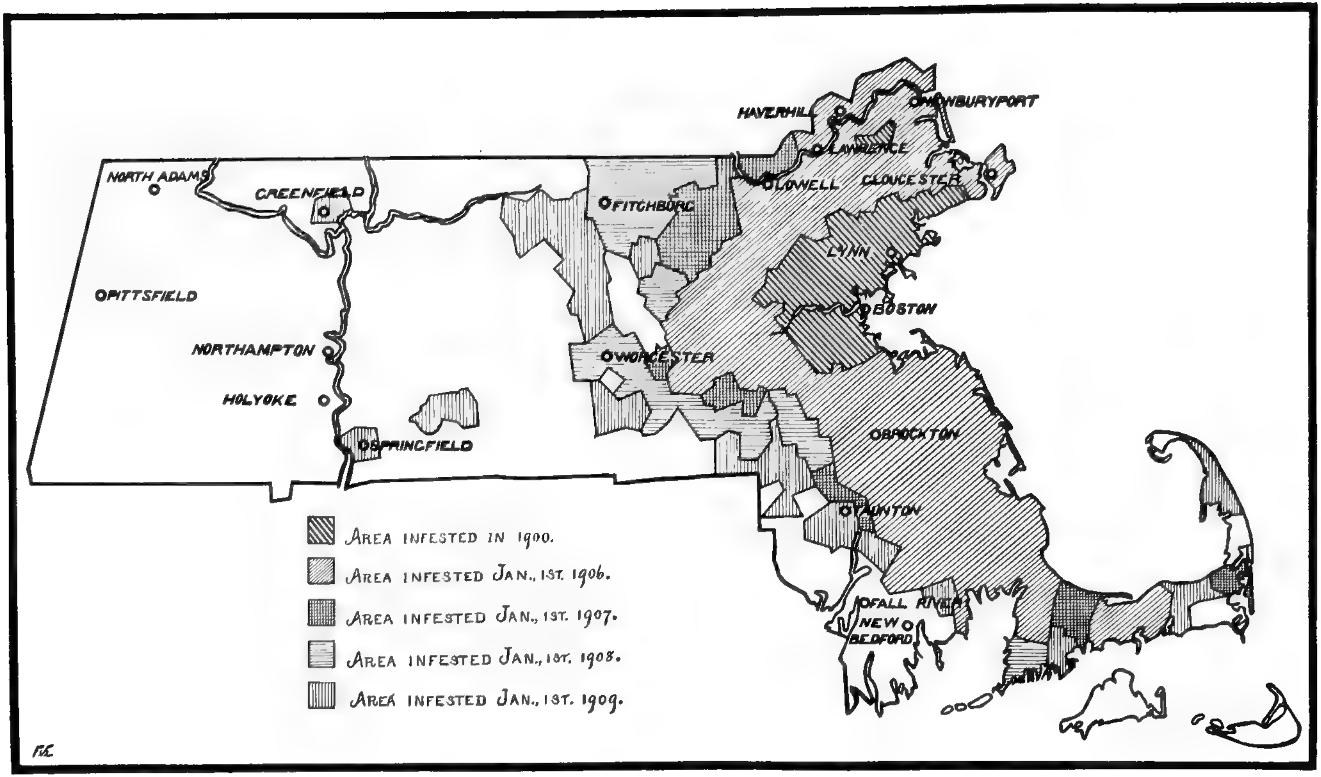
The following towns were found to be infested by the gypsy moth: —

Attleborough.
Bellingham.
Brewster.
Dennis.
Foxborough.
Gardner.
Lancaster.
Mansfield.
Mashpee.
Norfolk.
Oxford.
Princeton.
Rochester.
Sutton.
Taunton.
Templeton.
Wrentham.
Wellfleet.
Westminster.

It was also deemed advisable to scout the main road from Worcester to Springfield, and infestations were found in Warren, Palmer and Springfield. The main road leading to Hartford from Springfield was scouted as far as the Connecticut line, nothing being found outside of Springfield. Also, following up the Connecticut valley on the main highways, one egg cluster was found, in Greenfield. The State highway leading from Springfield to Westfield and Huntington was also inspected, but nothing was found. The following towns were inspected, but no gypsy moth infestations were found: —

Agawam.
Amherst.
Ashburnham.
Athol.
Auburn.
Barre.
Blackstone.
Brookfield.
Charlton.
Chicopee.
Deerfield.
Douglas.
Dudley.
Easthampton.
Fall River.
Granby.
Hadley.
Hatfield.
Holyoke.
Hubbardston.
Huntington.
Longmeadow.
North Attleborough.
North Brookfield.
Northampton.
Norton.
Orange.
Paxton.
Pittsfield.
Rehoboth.
Russell.
Rutland.
Seekonk.
South Hadley.
Southbridge.
Spencer.
Swansea.
Uxbridge.
Webster.
West Brookfield.
West Springfield.
Westfield.
Whately.
Wilbraham.

The policy of this office will be to continue the scouting operations on a small scale the coming year, especially in towns located



MAP SHOWING AREA INFESTED BY GYPSY MOTH JAN. 1, 1909.

inside the infested territory, as there is great danger of such towns becoming infested, that we may determine their condition at as early a date as possible. In some municipalities, where the infestation is slight and the work is not receiving proper attention from the local authorities, it may be advisable to make a thorough scout, that we may determine their condition, and be able to present the case to the local officials as it really is, thus making them understand the necessity of prosecuting the work vigorously.

LIST OF INFESTED TOWNS.

A complete list of cities and towns known to be infested by the gypsy moth Jan. 1, 1909, together with the liability under the act of each for 1909, and the name of the local superintendent of moth work in each town, is appended: —

TOWN OR CITY.	Liability.	Local Superintendent.
Abington,	$1,118 96	C. Frederick Shaw.
Acton,	722 99	Charles J. Williams.
Amesbury,	2,348 81	A. L. Stover.
Andover,	2,476 21	James H. Playdon.
Arlington,	4,442 02	William H. Bradley.
Ashby,	198 77	H. A. Lawrence.
Ashland,	470 02	Frank A. Morse.
Attleborough,	5,000 00	Wm. E. S. Smith.
Avon,	377 28	Willard W. Beals.
Ayer,	815 53	Loring A. Carman.
Barnstable,	2,277 15	Harry W. Bodfish.
Bedford,	520 30	W. A. Cutler.
Bellingham,	325 46	Henry A. Whitney.
Belmont,	2,431 46	Chas. F. Houlahan.
Berlin,	223 62	Willis Rice.
Beverly,	5,000 00	Josiah B. Brown.
Billerica,	909 78	Francis J. Dolan.
Bolton,	178 02	Charles E. Mace.
Boston,	5,000 00	D. Henry Sullivan.
Bourne,	1,356 60	Stillman B. Wright.
Boxborough,	99 58	John J. Sherry.
Boxford,	479 97	Charles Perley.
Braintree,	2,319 73	E. E. Abercrombie.

Town or City.	Liability.	Local Superintendent.
Brewster,	$210 63	Moses Wiles.
Bridgewater,	1,300 09	Robert J. McNeeland.
Brockton,	5,000 00	Edward Mottau.
Brookline,	5,000 00	Ernest B. Dane.
Burlington,	246 52	Walter W. Skelton.
Cambridge,	5,000 00	J. F. Donnelly.
Canton,	1,596 06	Augustus Hemenway.
Carlisle,	176 58	G. G. Wilkins.
Carver,	558 34	Herbert F. Atwood.
Chelmsford,	1,635 35	George B. B. Wright.
Chelsea,	5,000 00	J. A. O'Brien.
Clinton,	3,218 88	Michael Monahan.
Cohasset,	2,817 53	Joseph E. Grassie.
Concord,	2,551 71	H. P. Richardson.
Danvers,	2,352 60	Thomas E. Tinsley.
Dedham,	5,000 00	George A. Phillips.
Dennis,	475 87	H. H. Sears.
Dover,	560 85	G. H. Thompson.
Dracut,	919 20	Chester B. Colburn.
Dunstable,	119 46	James A. Davis.
Duxbury,	1,025 48	Henry A. Fish.
East Bridgewater,	786 16	William T. Greene.
Easton,	2,031 17	R. W. Melendy.
Essex,	436 53	Otis O. Storey.
Everett,	5,000 00	James Davidson.
Falmouth,	3,201 00	W. B. Bosworth.
Fitchburg,	5,000 00	Geo. H. Hastings.
Foxborough,	883 73	Frank C. Carpenter.
Framingham,	4,035 02	N. I. Bowditch.
Franklin,	1,476 97	Thomas Keefe.
Gardner,	2,942 78	T. W. Danforth.
Georgetown,	412 67	Edward J. Watson.
Gloucester,	5,000 00	W. D. Corliss.
Grafton,	1,069 86	Charles K. Despeau.
Greenfield,	3,645 72	William A. Ames.
Groton,	1,235 99	William Woods.
Groveland,	466 03	Moses M. Jaques.
Halifax,	205 39	Frank D. Lyon.
Hamilton,	1,441 27	Fred A. Nason.
Hanover,	577 74	Lyman Russell.

TOWN OR CITY.	Liability.	Local Superintendent.
Hanson,	$511 66	A. L. Dame.
Harvard,	481 67	George C. Maynard.
Haverhill,	5,000 00	George F. Moore.
Hingham,	2,307 82	Arthur W. Young.
Holbrook,	567 83	William Hayden.
Holden,	600 78	J. W. Rice.
Holliston,	630 30	Frank Cass.
Hopkinton,	618 44	Wm. A. Macmillan.
Hudson,	1,403 84	John E. Walsh.
Hull,	2,070 90	Smith F. Sturgis.
Hyde Park,	5,000 00	Harry G. Higbee.
Ipswich,	1,744 32	James A. Morey.
Kingston,	623 16	Carl C. Faunce.
Lakeville,	270 16	S. T. Nelson.
Lancaster,	1,461 23	John E. Thayer.
Lawrence,	5,000 00	William Howarth.
Leicester,	944 95	John J. Quinn.
Leominster,	4,210 52	S. R. Walker.
Lexington,	2,753 87	E. P. Merriam.
Lincoln,	1,124 13	Edward R. Farrar.
Littleton,	412 83	Alfred Hopkins.
Lowell,	5,000 00	Charles A. Whittet.
Lunenburg,	422 49	Stephen Farnsworth.
Lynn,	5,000 00	Albert C. Doak.
Lynnfield,	311 21	Alfred W. Copeland.
Malden,	5,000 00	George W. Stiles.
Manchester,	5,000 00	John D. Morrison.
Mansfield,	1,198 63	W. O. Sweet.
Marblehead,	2,987 21	Wm. H. Stevens, 2d.
Marion,	1,148 28	James H. Morss.
Marlborough,	4,021 23	M. E. Lyons.
Marshfield,	745 86	P. R. Livermore.
Mashpee,	80 22	Watson F. Hammond.
Maynard,	1,513 59	Albert Coughlin.
Medfield,	617 18	George L. L. Allen.
Medford,	5,000 00	Wm. J. Gannon.
Medway,	538 39	Frank Hager.
Melrose,	5,000 00	John J. McCullough.
Merrimac,	489 88	Frank E. Bartlett.
Methuen,	2,365 39	Alfred H. Wagland,

Town or City.	Liability.	Local Superintendent.
Middleborough,	$1,811 04	John C. Chase.
Middleton,	307 67	Benj. T. McGlauflin.
Milford,	2,800 46	Patrick F. Fitzgerald.
Millbury,	920 07	Edward F. Roach.
Millis,	320 32	Harris W. Alden.
Milton,	5,000 00	Nathaniel T. Kidder.
Nahant,	2,373 87	Thos. Roland.
Natick,	2,899 84	H. H. Hunnewell.
Needham,	2,262 22	Ernest E. Riley.
Newbury,	499 53	O. B. Tarbox.
Newburyport,	4,581 48	Charles P. Kelly.
Newton,	5,000 00	Charles I. Bucknam.
Norfolk,	322 73	C. Albert Murphy.
North Andover,	1,850 27	Peter Holt.
North Reading,	270 66	George E. Eaton.
Northbridge,	1,699 24	Arthur F. Whitin.
Norwell,	358 21	John H. Sparrell.
Norwood,	2,440 26	H. Frank Winslow.
Orleans,	245 67	Albert A. Smith.
Oxford,	747 67	Herbert E. Lovett.
Palmer,	1,629 01	C. H. Keith.
Peabody,	4,039 62	James F. Callahan.
Pembroke,	388 47	Calvin S. West.
Pepperell,	895 60	Jos. A. Wiley.
Plainville,	299 98	Geo. Cheever.
Plymouth,	4,179 44	George R. Briggs.
Plympton,	134 06	Zina E. Sherman.
Princeton,	416 55	J. Harry Allen.
Quincy,	5,000 00	Randolph C. Bainbridge.
Randolph,	802 52	James E. Blanche.
Raynham,	301 45	George M. Leach.
Reading,	2,095 45	Guy A. Hubbard.
Revere,	5,000 00	William G. Cook.
Rochester,	250 74	- -
Rockland,	1,511 99	Frank H. Shaw.
Rockport,	1,276 78	Eli Gott.
Rowley,	299 42	Daniel O'Brien.
Salem,	5,000 00	Amos Stillman.
Salisbury,	359 39	Charles M. Pike.
Sandwich,	400 10	B. F. Denison.

Town or City.	Liability.	Local Superintendent.
Saugus,	$2,054 48	Thomas E. Berrett.
Scituate,	1,661 85	Percival S. Brown.
Sharon,	1,030 79	T. J. Leary.
Sherborn,	564 15	J. P. Dowse.
Shirley,	439 31	John E. L. Hazen.
Shrewsbury,	598 21	Frank L. Ott.
Somerville,	5,000 00	Asa B. Prichard.
Southborough,	706 45	Harry Burnett.
Springfield,	5,000 00	Wm. F. Gale.
Stoneham,	2,010 93	George M. Jefts.
Stoughton,	1,402 83	Wm. P. Kennedy.
Stow,	357 22	J. Frank Robbins.
Sudbury,	497 76	Wm. E. Baldwin.
Sutton,	492 79	John E. Gifford.
Swampscott,	3,997 06	L. Herbert Cahoon.
Taunton,	5,000 00	Alvaro Harnden.
Templeton,	637 93	John B. Wheeler.
Tewksbury,	458 39	Harry M. Briggs.
Topsfield,	501 98	C. W. Floyd.
Townsend,	460 92	Henry H. Jennerson.
Truro,	150 96	Joseph H. Atwood.
Tyngsborough,	209 87	D. A. Lawrence.
Upton,	441 12	George H. Evans.
Wakefield,	3,441 43	W. W. Whittredge.
Walpole,	1,671 86	Philip R. Allen.
Waltham,	5,000 00	Richard A. Jones.
Wareham,	1,508 32	J. J. Walsh.
Warren,	758 74	Alfred A. Warriner.
Watertown,	5,000 00	John C. Ford.
Wayland,	884 84	George W. Fairbank.
Wellesley,	5,000 00	Fletcher M. Abbott.
Wellfleet,	392 38	Freeman A. Snow.
Wenham,	935 63	Jacob D. Barnes.
West Bridgewater,	488 69	Octave Belmore.
West Newbury,	424 49	William Merrill.
Westborough,	1,273 09	William H. Sullivan.
Westford,	700 98	Harry L. Nesmith.
Westminster,	308 50	Stillman Whitney.
Weston,	2,711 61	Edward P. Ripley.
Westwood,	926 67	Fred A. McIlroy.

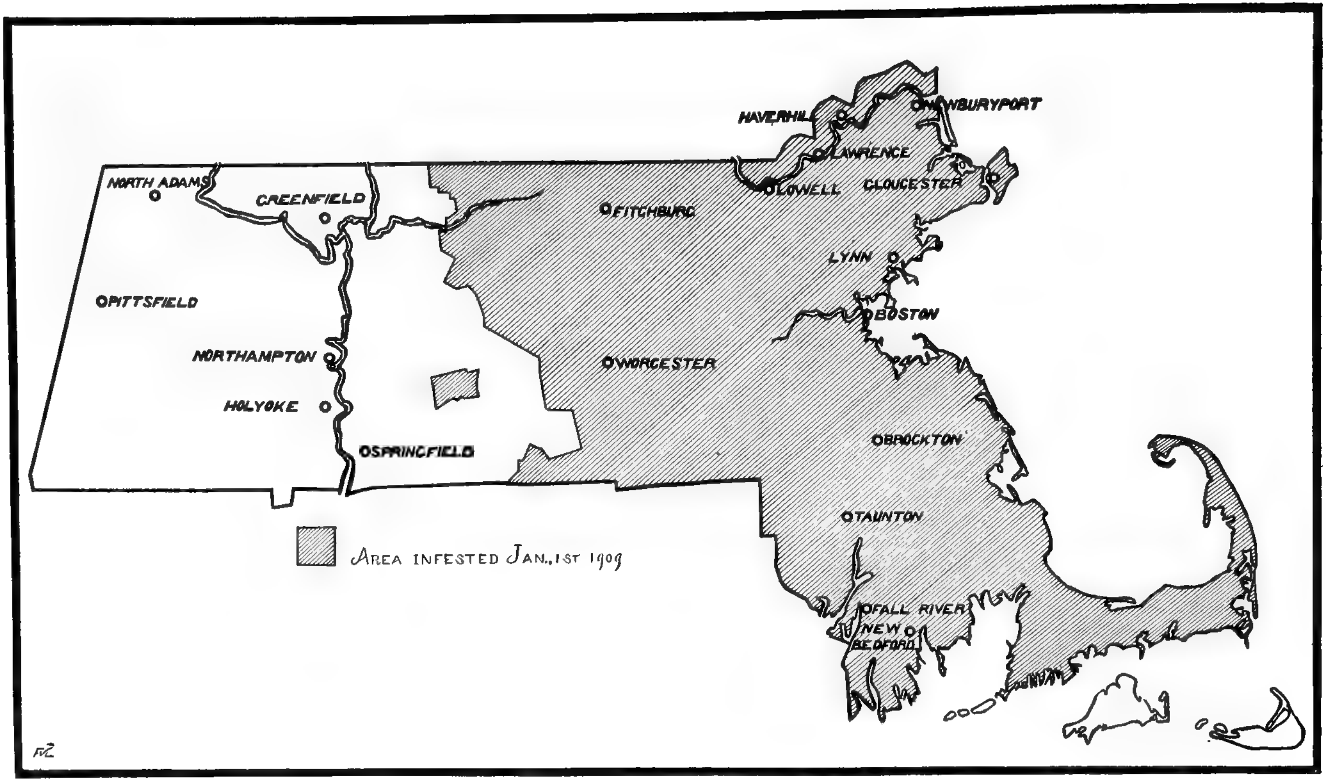
Town or City.	Liability.	Local Superintendent.
Weymouth,	$3,064 06	Dummer Sewall.
Whitman,	1,896 61	Clarence A. Randall.
Wilmington,	528 36	Oliver McGrane.
Winchester,	4,606 56	Samuel S. Symmes.
Winthrop,	4,303 07	Chas. F. Hilly.
Woburn,	4,476 08	John H. McGann.
Worcester,	5,000 00	J. H. Hemingway.
Wrentham,	476 15	H. A. Cowell.
Yarmouth,	811 96	Charles R. Bassett.

The Brown-tail Moth.

In 1907 the brown-tail moth was not as abundant as in previous years, and we did not think it necessary to determine the extent of the infestation, as the possibility of exterminating this moth is very small. The infestation is more serious this year, and it is important that we should know its extent. We therefore employed a few men after the leaves had fallen, to scout the towns on the border of the known infested district. As a result of this scouting the brown-tail moth has been found to extend on the northwest as far as Royalston, on the southwest as far as Southbridge, and in the central part of the State as far west as Ware. The infestation also extends to the extreme end of Cape Cod, to the New Hampshire line and to the coast, making an area in all of 5,147 square miles infested by the brown-tail moth.

Future Work.

In the year 1909 the work should be carried on along practically the same lines as in the past, by creosoting gypsy moth egg clusters, removing brown-tail moth webs and thinning out woodlands in the winter, and by spraying, burlapping and tanglefooting during the caterpillar season. In a large percentage of the severely infested districts the greater part of the work for the coming year will be in woodlands, where it will be necessary to carry on extensive spraying operations. Several large power outfits have been purchased, and it is hoped



MAP SHOWING AREA INFESTED BY BROWN-TAIL MOTH JAN. 1, 1909.

that more will be in the field before the opening of the caterpillar season, thus giving us a better chance to check the moths in these localities. In the generally infested section it will be well to keep a close watch on the woodlands, that the infestation there may not become serious, thus saving the costly work under such conditions, which several of our cities and towns have been obliged to undertake. In the slightly infested localities the work should have extermination in view at all times, and, if possible, all small infestations should be stamped out. It is also very necessary that the snow-line cleaning should be carried on as in the past, as it relieves all engaged in the work of much anxiety, if we are fortunate enough to have a large amount of snow during the winter months. It is also necessary, where funds will permit, to carry on as extensively as possible the tin patching and cementing of cavities in infested orchards, and also the removal of decayed trees. There is no other method of work that will assist us so much in putting our colonies into good condition in the residential sections as this work.

Special Work in Parks.

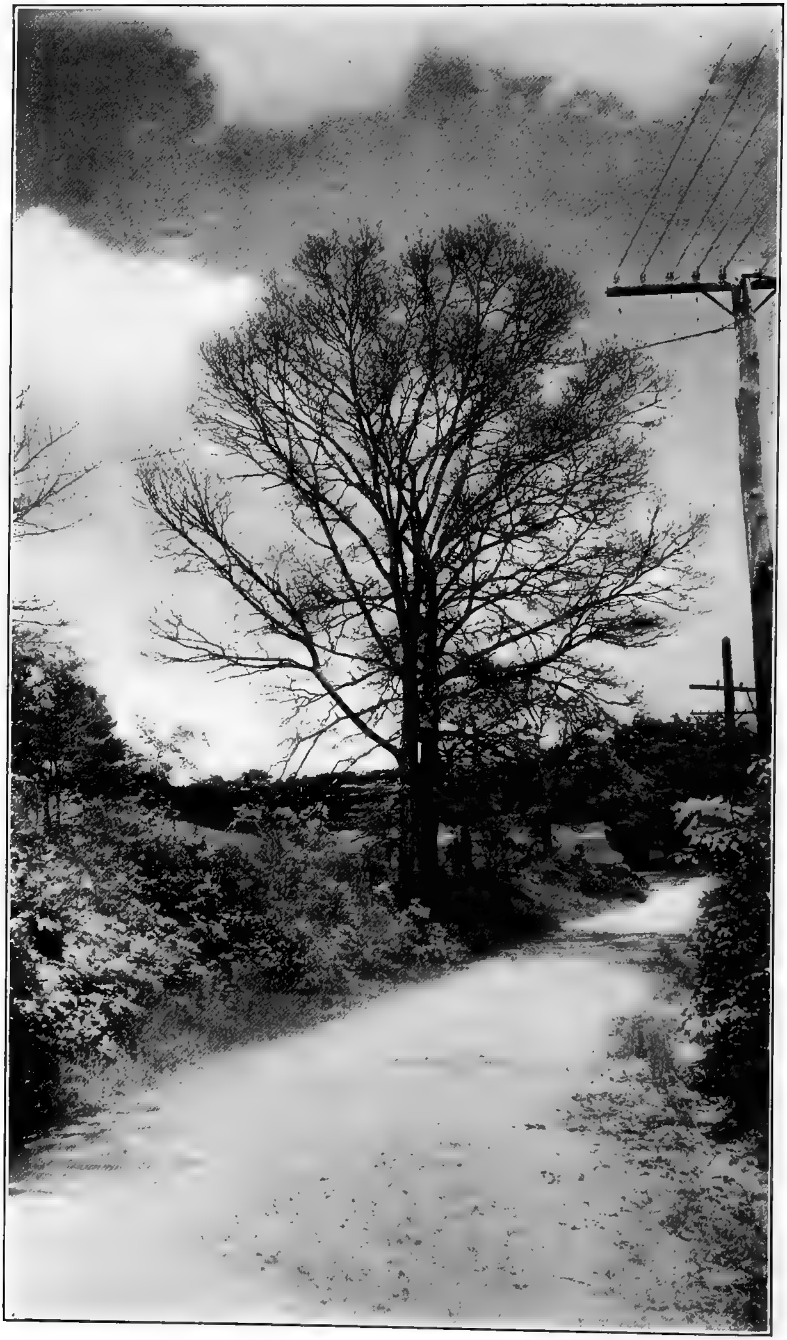
During the year 1908, as in 1907, this office has, with the approval of His Excellency the Governor, deemed it wise to give assistance to several municipalities in which were located badly infested parks, and where the cost of clearing would be more of a financial burden than the city or town could stand. The following places were given consideration: Pine Banks Park, Malden and Melrose; Prospect Hill Park, Waltham; Lynn Woods, city of Lynn; Shaker Glen, Woburn; Mt. Ann Park, Gloucester.

In Pine Banks Park it was necessary to do a considerable amount of thinning, and the greater part of the egg clusters were treated. This was done with the understanding that the trees would be sprayed by the cities of Malden and Melrose, but when the time arrived it was impossible to get them to do this work. We were fortunate enough, however, to have the assistance of the United States government, and the larger part of the park was sprayed by them. During the fall more thinning was done, and the park at the present time is in better condition than it has been since the work started. If it is properly sprayed the coming season there will be no danger whatever of defoliation there.

In Prospect Hill Park the infestation was very serious, and it seemed that unless a large amount of work was done there the larger part of it was destined to be defoliated. As the condition of Waltham proper was very bad, and as so much work was necessary, it became evident that the city authorities would not be in a position to care for it; therefore, with the approval of His Excellency the Governor, this work was given to a responsible contractor who was the lowest bidder. Thinning operations were carried on over the entire area, and some protective belts were made where there was great danger of the caterpillars migrating from adjoining properties. These protective belts were tanglefooted, and when the foliage appeared, the entire park and a protective border, containing about 200 acres, were sprayed with arsenate of lead. Very good results were obtained, and if the park is properly cared for this winter, next season it should be in very good condition.

In Lynn Woods work was carried on somewhat extensively from the early spring through a part of the caterpillar season. Thinning out of trees was done, roadsides were protected in most cases, and where white pine was abundant the deciduous growth was removed and the pines tanglefooted. Some portions of the park were burned over during the caterpillar season, thus checking the insects to a great extent. This park must be given very careful attention in the future, so that it may not be seriously damaged by the ravages of the gypsy moth caterpillars. To care for this area of 1,000 acres properly is a hard problem, as it means a large expenditure of money, and it must be most systematically done in order that good results may be obtained. The sections of the city of Lynn bordering on this park suffer constantly from reinfestation from this source.

Shaker Glen is not a public park, but is owned by private individuals and much frequented by the public. Inasmuch as it was seriously infested, it was deemed advisable last year to start thinning operations, treat the egg clusters and put it in condition for spraying. Later in the season, as the caterpillars hatched, a



OAK TREE IN DRACUT STRIPPED BY BROWN-TAIL CATERPILLARS, JUNE, 1908.

great portion of it was sprayed, and at the present time it is in very good condition, although some work on its borders should be done. We hope to do this protective work during the winter.

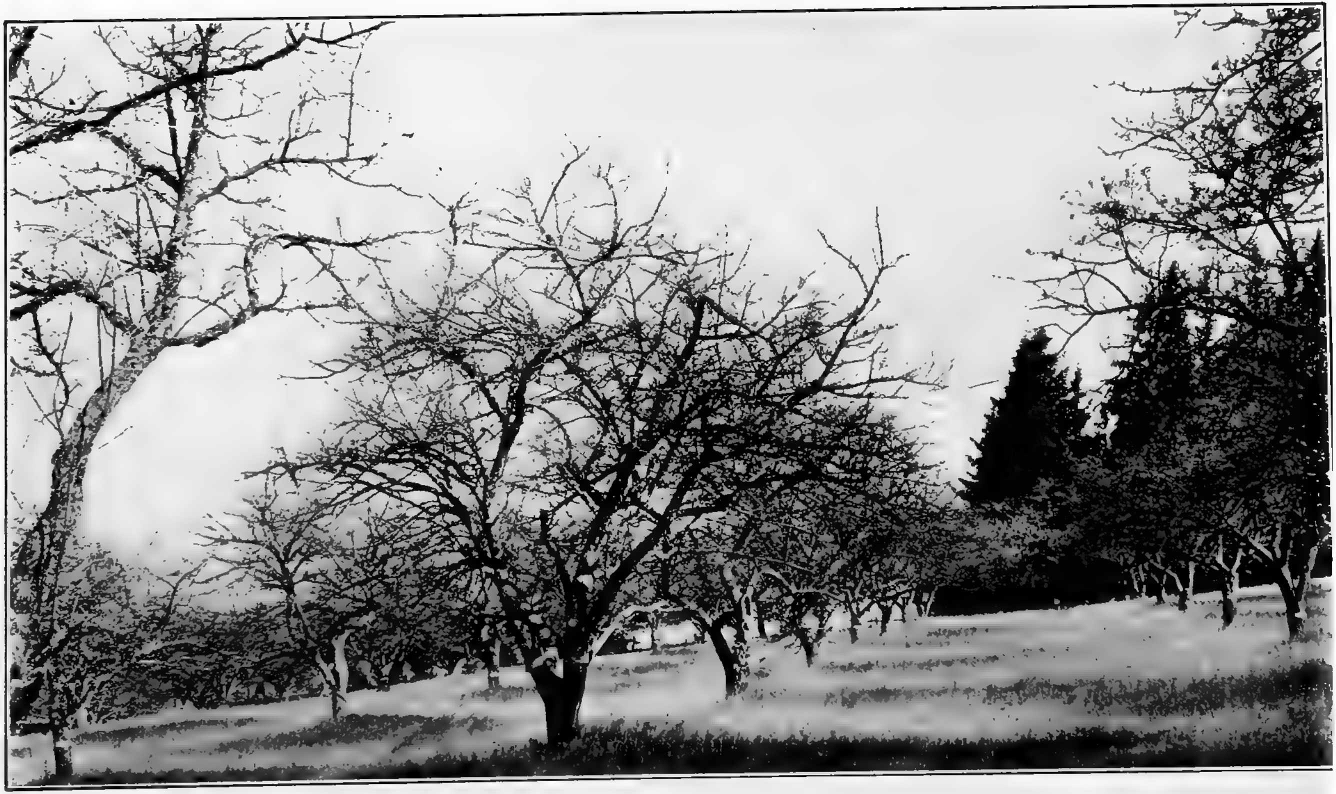
Mt. Ann Park, Gloucester, was found to be in a serious condition, and we were called upon by the board of trustees to assist them in the work of cleaning the same. After making a slight inspection of the park it was found necessary to do some thinning, and the whole area, consisting of some 50 acres, was scouted very thoroughly, the gypsy moth egg clusters being treated as found. During the caterpillar season some burlapping was done in the worst infested parts. The coming season it will be necessary to thin about half of the area and do thorough work later on. The next caterpillar season it should be thoroughly sprayed. The borders of this park are also in very bad condition, and it will be necessary to use some protective measures to combat the moths.

Condition of Infested District.

In former reports submitted by this office the condition of each town infested by the gypsy moth has been briefly summarized, but as the towns doing work against the gypsy and brown-tail moths have greatly increased in number, we feel that a general summary of the territory will give all the information necessary.

A noticeable gain has been made the past season, especially in the residential sections, where great efforts have been made, as it is from such sections that the danger of distribution comes. As there are about 10,000 miles of streets whose borders are more or less infested by the gypsy moth, to care for them alone requires a large expenditure of money. Practically the whole of this mileage of streets receives inspection by the trained employees of this office, that extra precaution may be taken against the spreading of the moths. The work now done on private estates by cities and towns is of a better quality than in past years, assuring the property owners satisfaction in the work and security from annoyance during the caterpillar season. Property owners seem also more willing this year to pay the moth tax that the law allows the cities and towns to collect, thus showing appreciation of the fact that the work has been well done. The possibility of the caterpillars migrating from private estates is also eliminated to a great extent. In many of the cities and towns work has been done in the most important woodland colonies, especially those bordering on residential sections, in order that reinfestation of cleaned estates shall not occur, and the results of previous work thus be lost. In some of the farming sections, where the gypsy moth infestation is serious, the work is greatly handicapped by the large numbers of worthless apple trees, which should be removed or in which the cavities should be filled up, in order that good results may be obtained. These conditions require a large expenditure of money, and exist in towns of low valuation, where the liability is small, thus necessitating that the State provide a large part of the funds for the work to be done. It consequently results that our appropriation will allow us to do but a limited amount of this work each year. It is hoped that the property owners in sections where these conditions exist will co-operate as much as possible with the local authorities, and that they will follow our suggestion, — that a few good trees are better than a large number of poor ones. If the owners will act on this suggestion and give such assistance as they can, a great deal more spraying can be done, the quality of the fruit will be better, and in time the farmers will profit financially. In other localities there are immense tracts of woodland, which handicap both the State and the town in making the necessary progress; and in such places the only practical work to be done is to make protective belts, so that the caterpillars will not migrate to adjoining property now under control and increase the infested area. Large tracts of white pine growth can be handled very easily by removing the deciduous trees and banding the pines with tanglefoot. This treatment has been thoroughly investigated, and is believed to be perfectly safe.

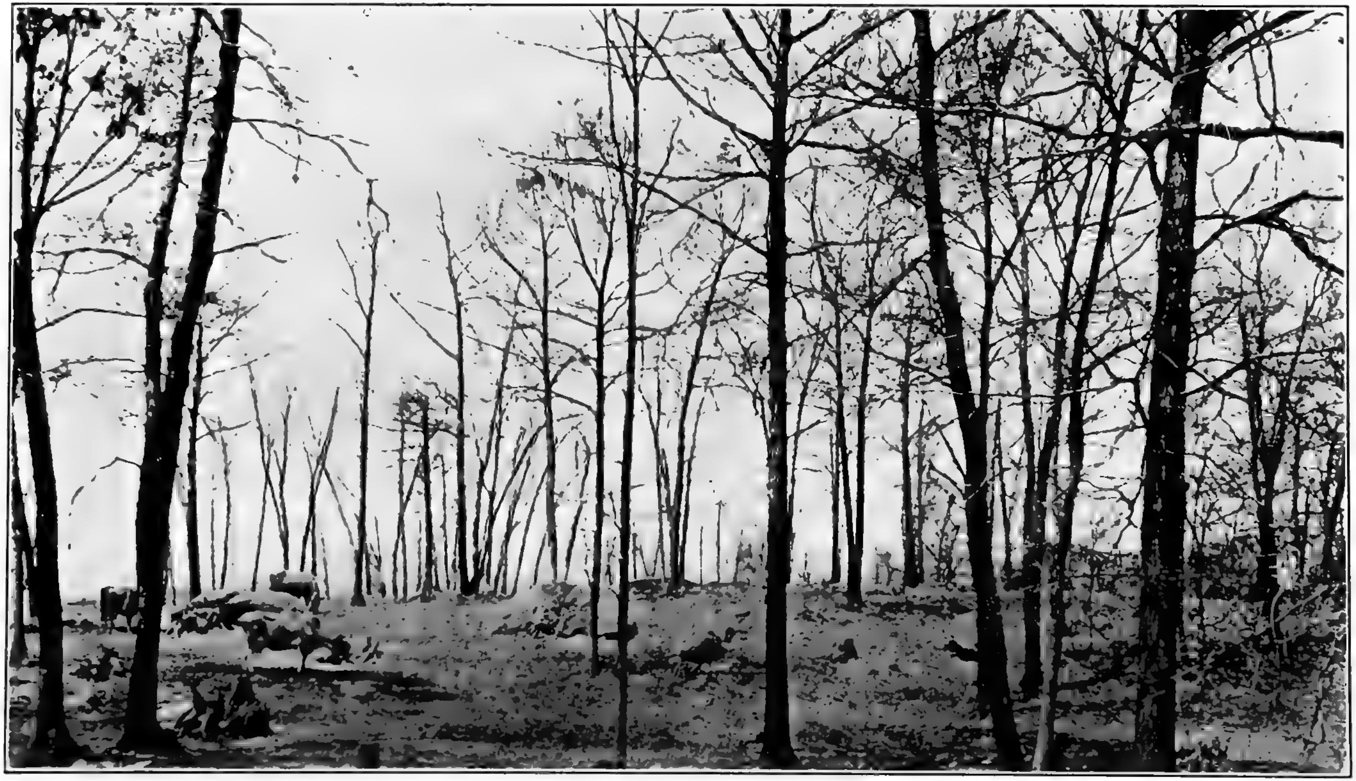
The gypsy moth infestation over the entire State may be divided into three distinct classes: viz., severe, general, and slight. In the severely infested section a large expenditure of money has been made, as it was necessary that thorough work should be done in order to control the spread of the gypsy moth. In this section are comprised some of the wealthiest towns in the



ORCHARD ON SHAW ESTATE, CORNER OF ANDOVER STREET AND BALD PATE ROAD, GEORGETOWN, CONTAINING 169 FRUIT TREES STRIPPED BY BROWN-TAIL CATERPILLARS, JUNE 12, 1908.

State, and the question of dealing with the gypsy moth promises to be one of the most important problems for these towns in the future. If sufficient funds are not made available for moth work the coming year, great damage will occur in a number of places and the beauty of many large estates will be seriously impaired. During the past caterpillar season Brookline, Newton, Waltham and Georgetown suffered to a considerable extent from stripping in both the residential and woodland sections. At this writing Brookline and Newton are showing more interest than formerly, and seem to appreciate the danger before them. They are now pushing the work more vigorously than ever before. In Waltham, unless more efficient and extensive work is done, severe damage and much annoyance from the caterpillars will be experienced next season. In Georgetown the brown-tail moth caused serious damage in several large orchards. The gypsy moth infestation also is of such a kind that more care must be exercised in the coming season to avert serious damage in many places. The liability of the towns in this class and the allotments which the State is able to make will not be sufficient to check the moths, and some co-operative measures must be adopted to continue the necessary fight, and put the colonies in a proper condition to be handled economically in the future. Many owners of estates are expending large sums of money in ridding their property of the pests, and they should receive some protection. Where they are surrounded by woodland, this protective measure would necessitate the expenditure of large sums of money, so it will readily be seen that other resources than the State and town will have to be drawn upon in such places. In several localities where the infestation is very bad, citizens are purchasing large spraying outfits for their own use, and in some cases loaning them to the local authorities. Other cities and towns are electing committees to act with the local superintendent of moth work in raising funds from individuals to be expended under the direction of the local authorities, and in other places the members of improvement societies are leaving their estates in the hands of the local authorities, agreeing to pay the whole expense incurred on their estates for the year. It is often of value for the local authorities to interview property owners who have large holdings, and ask their co-operation, thus increasing the amount of money with which to work. Some of the municipalities that are severely infested are not fortunate enough to have wealthy land owners, and here the burden of the expense falls almost entirely upon the city or town and the State, and only a limited amount of work can be done each year, and only the most important sections can receive treatment. The work now needed most is in the woodlands in towns of low valuation, where but a very small amount can be charged to the owner. In several places the owners of large tracts of timber land are awakening to the danger which confronts them, and are clearing their lands, that they may derive what revenue they can from the timber before it is too late.

In the generally infested sections excellent results are being accomplished, and the cities and towns in this class seem to realize that the work must be prosecuted vigorously, in order that they may not become seriously infested. The residential sections are receiving very thorough treatment each year, and the woodlands are being scouted to protect them from serious colonies. This is somewhat expensive treatment, but it is best in the end. We can safely say that the generally infested cities and towns are making headway in their fight against the gypsy moths, and that no serious damage has as yet developed. Extra precaution is taken during the caterpillar season by tangle-footing and burlapping the trees, and spraying in the worst-infested places. The burlaps are watched during the summer season, and the number of caterpillars have been decreased. Some property owners in the generally infested towns are having their woodlands thinned so that they can be cared for economically, and also so that the remaining trees may have a better chance to grow. In some localities, where roadside thinning was thought advisable, it was opposed on the ground that the natural beauty of the roads would be destroyed. However, when it was found that only a short time was required for a new growth of shrubbery, this opposition was withdrawn. In several woodland colonies, where thinning was necessary, there was opposition on the part of the owner; but after the work was performed, and the thinning was found to be done scientifically, the work obtained approval. Many of the cities and towns that are generally in-



WOODLAND STRIPPED BY GYPSY MOTH CATERPILLARS, NEWTON, JULY, 1908.

fested have the necessary apparatus with which to fight the moths in bad colonies, in this way preventing any serious outbreaks. Within this district there are a great many private parks and beautiful pine groves, and the owners have shown a co-operative spirit and at a great expense given them good care, and thus the danger of distribution which exists in such places has been avoided.

In sections where but a slight infestation occurs, exterminative methods are being used, with good results. Most of these infestations are comparatively new, and the local forces have required a large amount of assistance from the trained employees of this office. After the infestations were found by our scouting gangs the city or town officials were notified, and the work was begun at the expense of the town, and in most cases their liability was large enough to cover the same. Very thorough cleaning was done before hatching time in the spring, and followed up during the caterpillar season with burlapping, and in many instances the colonies were exterminated. In other places but few caterpillars were found, and in only a few cases did we find further infestation last fall. In this section the local forces have been very willing to follow our suggestions, and seem anxious to do the best possible work, that they may have good results to show. It is hoped that instead of the infested area increasing in the future by the finding of new colonies, we may be able to reduce it by stamping out slight infestations in the outer towns.

In general, the work has been performed in a very satisfactory manner, and a great gain has been made. In some cases local officials have not realized the importance of the work, and have needed considerable urging. The municipalities where this office has been obliged to take legal measures to enforce the law are very few, and they are being watched closely, to see that their condition does not become such as to prove a menace to neighboring cities and towns. The local forces are improving steadily in the quality of their work, and are making better progress and covering a much larger area than in the past.

WORK OF OTHER STATE BOARDS, ETC.

We wish again to acknowledge the help given in our work by other State boards and commissions, by State institutions and private corporations.

Particularly effective and helpful has been the work of the Metropolitan Park Commission, Massachusetts Highway Commission, Metropolitan Water and Sewerage Board, Massachusetts Board of Insanity, Massachusetts School for Feeble-minded, and the McLean Asylum. We append herewith reports from some of these boards.

METROPOLITAN PARK COMMISSION,
CONGREGATIONAL HOUSE, 14 BEACON STREET, BOSTON, Jan. 16, 1909.

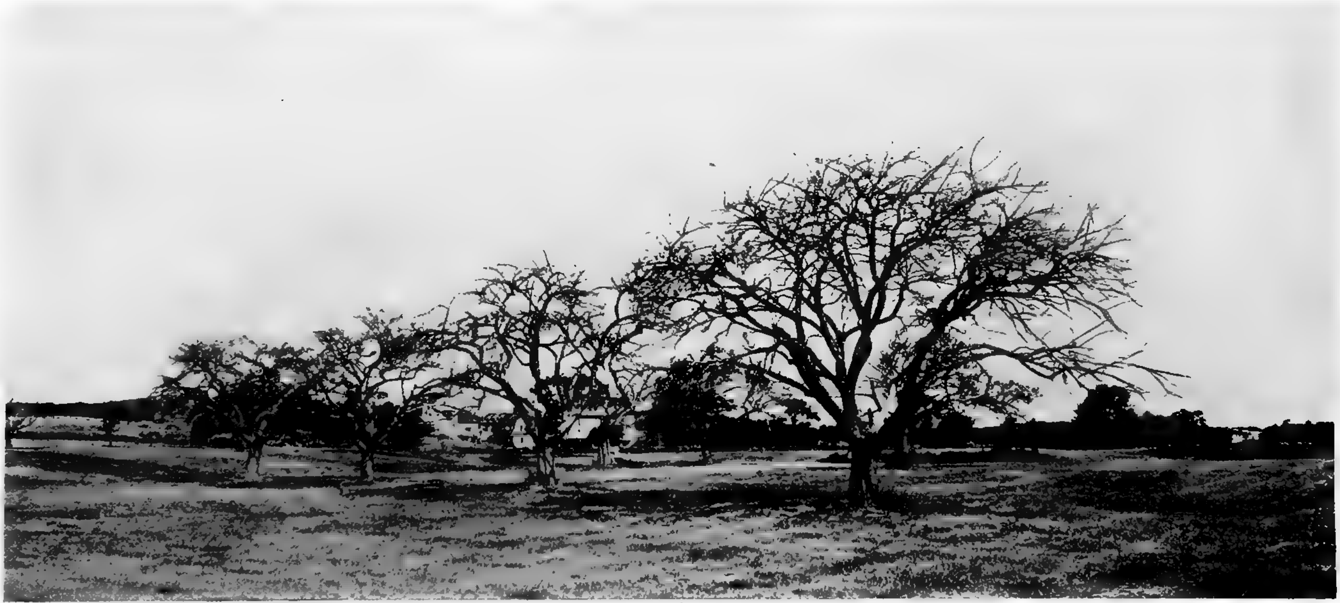
Mr. L. H. WORTHLEY, *Acting Superintendent, 6 Beacon Street, Boston, Mass.*

DEAR SIR: — The Metropolitan Park Commission has no special report to make in regard to the work against gypsy and brown-tail moths in 1908. The work has proceeded upon the same general lines as in previous years, and has proved very successful. Spraying by large power machines was tried over considerable areas, with very good results. The work now seems to have advanced to a point where spraying can be relied upon to a much larger extent than heretofore. A consequent reduction in expense over the same areas may be expected. The general expense, however, will not be reduced, because of the increase along the outside lands on the southerly borders of Blue Hills, and because of the sudden coming back of the brown-tail moths and the invasion of elm-tree beetles. The general condition of the work, however, is satisfactory, and an advance over previous years.

Very truly yours,
W. B. DE LAS CASAS,
Chairman.

Work done on State Highways.

As in the year 1907, we were again requested by the Massachusetts Highway Commission to take full charge of the work during the year 1908. The work was carried on along practically the same lines, and a considerable amount of thinning was done. As the spring opened, it became apparent that extensive spraying operations would be necessary to keep the gypsy moth in check, and also prevent damage from the elm-leaf beetle, an insect pest which was very prevalent during the summer months. Nearly all sections of the State highway



FRUIT TREES KILLED BY THE GYPSY MOTH, WALTHAM, JULY, 1908.

along which thinning of trees and cleaning operations had been carried on previously were thoroughly sprayed with arsenate of lead, with satisfactory results. In some sections it was necessary to burlap the trees to the extent which our funds would permit, in order to destroy the caterpillars which swarmed in from adjoining infested localities. It has been our aim to make protective belts where serious infestations bordered on the State highway, that the roadsides might not become reinfested after being thoroughly cleaned. In the Cape Cod district, where but few gypsy moths were found, spraying operations for the elm-leaf beetle were carried on extensively. In the fall months the sprout growth which had sprung up in places where the trees had been previously thinned was cut over, and after the leaves had fallen, the work of clearing the trees of egg clusters and nests was begun. At this writing nearly all of this work has been completed, and our fall inspection shows a marked improvement along roads. Nearly all the work on the State highway has been done by the local gypsy moth forces of the various cities and towns, as we are assured that these trained bands of men have now reached a high degree of efficiency. In some places, however, it was necessary to employ responsible contractors for certain emergency work in connection with the insect pests. In some cases, where thinning operations on the State highway were necessary, we have been fortunate enough to obtain the services of the United States Department of Agriculture, thus receiving valuable assistance without cost. We feel that it will be necessary for this work to be continued, as in some cases the trees along the highway are liable to reinfestation from various causes, and we shall keep them continually under surveillance. All told, there was expended in this work up to Dec. 1, 1908, $6,584.25. Work has been done on the State highway trees in the following cities and towns: —

Acton.
Amesbury.
Andover.
Ashland.
Barnstable.
Bedford.
Beverly.
Bourne.
Boxborough.
Brewster.
Chatham.
Chelmsford.
Cohasset.
Concord.
Dennis.
Dover.
Dracut.
Duxbury.

Falmouth.
Framingham.
Gloucester.
Groton.
Groveland.
Hamilton.
Harvard.
Hingham.
Hudson.
Ipswich.
Leominster.
Littleton.
Marlborough.
Melrose.
Merrimac.
Methuen.
Natick.
Needham.
Newbury.
Newburyport.
North Andover.
Northborough.
Orleans.
Quincy.
Reading.
Rockland.
Rowley.
Salisbury.
Sandwich.
Scituate.
Southborough.
Stoneham.
Sudbury.
Swampscott.
Tewksbury.
Townsend.
Truro.
Watertown.
Wayland.
Wellesley.
Wellfleet.
Wenham.
West Newbury.
Westborough.
Westford.
Weston.
Weymouth.
Winchester.
Yarmouth.

Metropolitan Water and Sewerage Board,
Boston, Jan. 25, 1909.

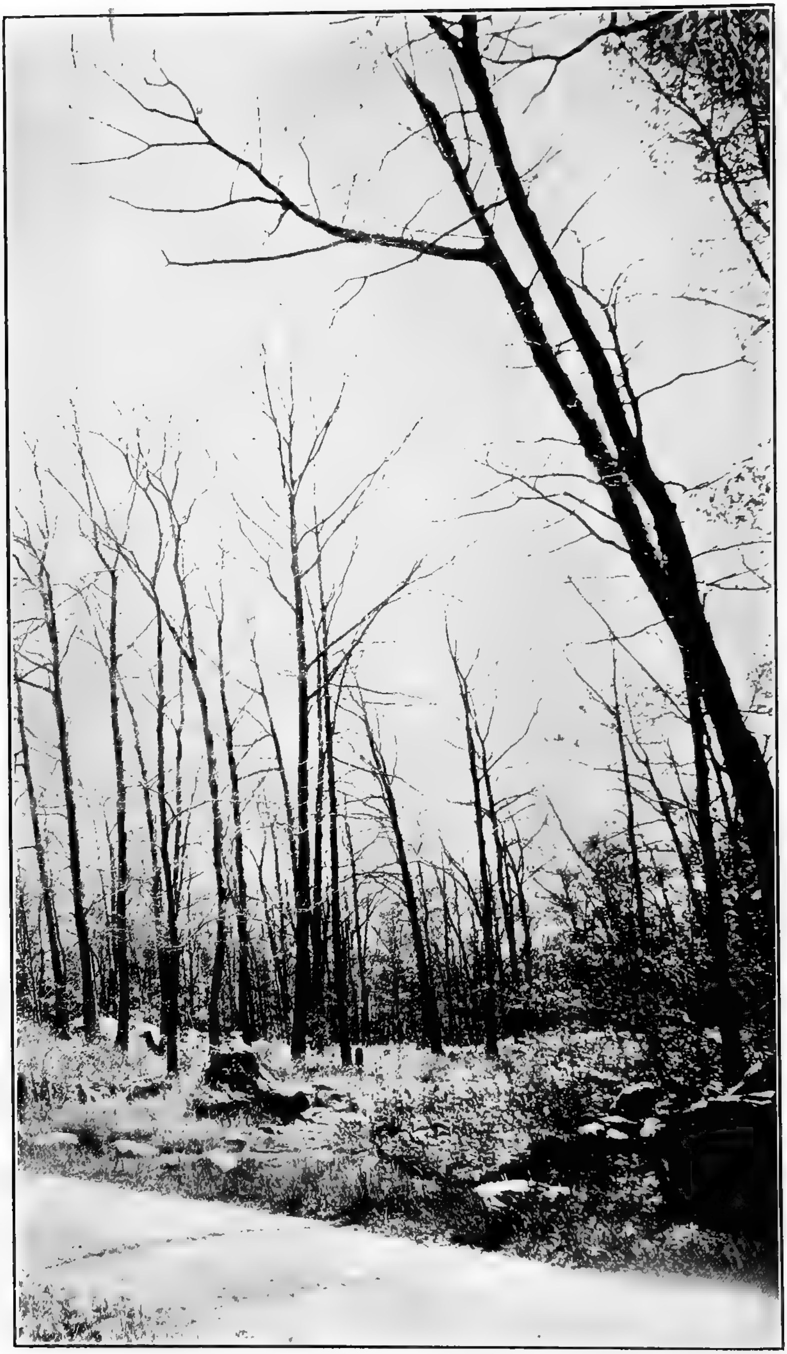
Leon H. Worthley, Esq., *Acting Superintendent.*

Dear Sir: — In reply to your request that our Board should furnish you with a brief statement of its work against the gypsy and brown-tail moths and other pests on lands under its supervision during the past year, I submit the following: —

During the year 1908 a sum amounting to about $7,500 was expended for the purpose of protecting trees on the lands of the metropolitan water works from injury by the gypsy and brown-tail moths, the elm beetles and the pine tree weevils. This sum was about $3,200 less than was expended during the previous year, as the thorough work done on the property at Spot Pond during the past few years has materially reduced the cost of keeping the gypsy moths under control.

The methods followed have been the same as in previous years, namely: painting the egg clusters of the gypsy moths with a mixture of creosote and fuel oil; cutting off and burning the nests of the brown-tail moths; banding the trees with tanglefoot early in the spring, to prevent the caterpillars from ascending the trees; spraying with arsenate of lead all trees which were found to be infested with moths; and banding with burlap the trees in places where moths were known or suspected to be present, and destroying the full-grown caterpillars which collected under the burlap. Trees infested with elm beetles were sprayed with arsenate of lead, and the trees were scraped from the ground to a height of 8 or 10 feet.

The numbers of the gypsy moths have decreased, but the brown-tail moths and the elm beetles have increased in large numbers, as compared with the previous year. Gypsy moths have, however, been found in



WOODLAND STRIPPED BY GYPSY MOTH CATERPILLARS
BROOKLINE, JULY

Framingham at points farther west than before. No gypsy moths have as yet been discovered on the water works property around the Wachusett reservoir, but the number of brown-tail moths has increased in the vicinity of the Wachusett dam, and a few have been destroyed in West Boylston at the upper end of the reservoir.

The young pine trees on lands around the Wachusett and Sudbury reservoirs, of which about 1,000,000 have been planted during the past six years, were in the middle of the summer found to be infested with the pine tree weevil, which cuts off the young shoot, generally the leader at the top of the tree. The weevils were destroyed by cutting off and burning the affected shoots.

The work of cutting underbrush and undesirable trees which afford lodging places for the moths has been continued during the year.

The work of protecting the trees has been, as in previous years, carried on under the supervision of Mr. Dexter Brackett, the chief engineer of the metropolitan water works.

Yours very truly,
HENRY H. SPRAGUE,
Chairman.

NATIONAL AID.

The work done this year by the United States Department of Agriculture has been most commendable, and the results obtained in the work of preventing the spread of the moths have been gratifying and helpful to this office. The method used by this department is very thorough, and as a rule the work has been done where it would have been impossible for the State or the infested municipalities to have undertaken it. The work has been principally along well-travelled thoroughfares bordered by woodland. It is very evident that the Commonwealth would have suffered much more than it has from the spreading of the moths if the roadsides had not been cleared by the work of the Department of Agriculture.

In the following report of D. M. Rogers, field agent in charge of the work, a few details of the work will be found. Due credit for this work should be given those instrumental in securing the government appropriations.

REPORT OF SPECIAL FIELD AGENT D. M. ROGERS, UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF ENTOMOLOGY, WASHINGTON, D. C.

Our work during the year 1908 towards preventing the spread of the moths has been very similar to that done in previous years. We have continued work along the woodland roadsides where most infested with the gypsy moths; we have cleared the ground of underbrush and undesirable trees; pruned the trees; creosoted the gypsy moth egg clusters; cut and burned the brown-tail webs; burlapped, tanglefooted and sprayed strips 100 feet wide in 30 cities and towns, as follows: —

- Bedford.
- Belmont.
- Billerica.
- Burlington.
- Concord.
- Dedham.
- Gloucester.
- Lexington.
- Lincoln.
- Lynn.
- Lynnfield.
- Malden.
- Melrose.
- Natick.
- Needham.
- Newton.
- North Reading.
- Peabody.
- Quincy.
- Reading.
- Salem.
- Saugus.
- Stoneham.
- Swampscott.
- Wakefield.
- Waltham.
- Wayland.
- Weston.
- Wilmington.
- Woburn.

We have now about 230 miles of these roadside strips being cared for, doing practically all of the work against the moths on them. In the last calendar year our Massachusetts force has varied in number from 105 men in August to 242 men in December.

Resolution adopted by the American Association of Economic Entomologists.

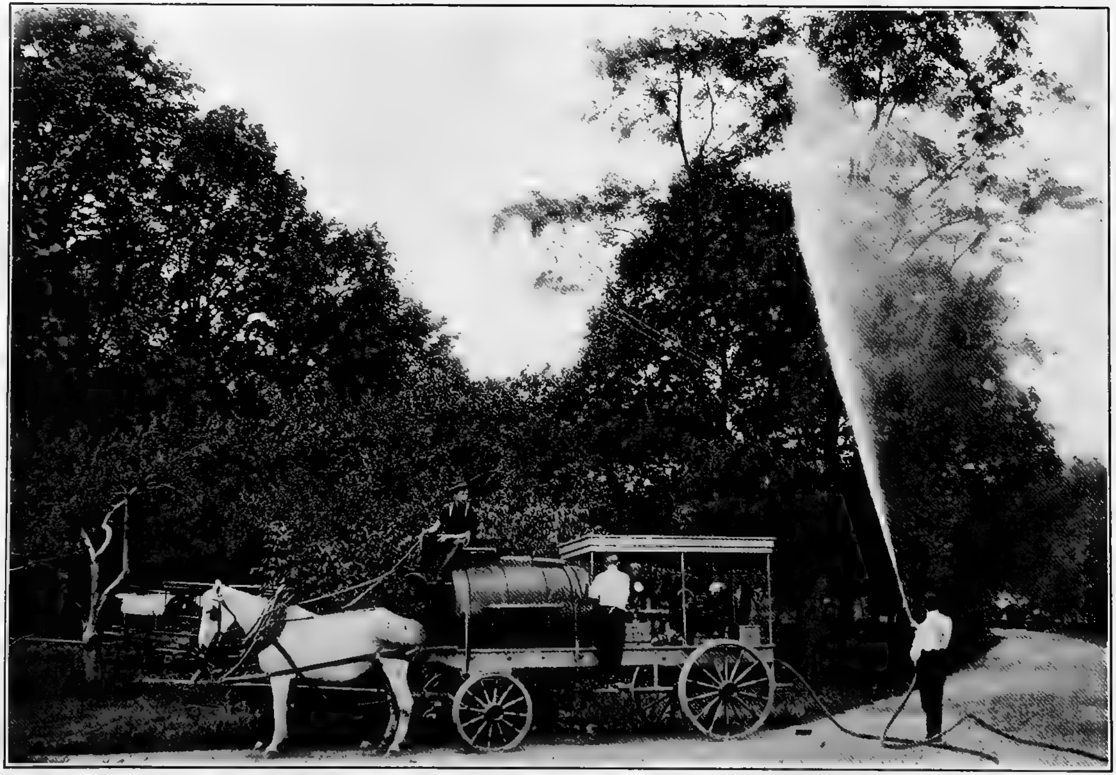
At the twenty-first annual meeting of the American Association of Economic Entomologists, held Dec. 29, 1908, at Baltimore, Md., the following resolution was adopted: —

> *Resolved,* That we again place on record our conviction that the control of the gypsy moth in New England is an entomological problem of the first magnitude, and of great practical importance to the entire country. Furthermore, we would emphasize the necessity of the State of Massachusetts continuing with undiminished vigor the policy prosecuted so ably during the past few years.

Adopted Dec. 29, 1908. Signed by the committee on resolutions: E. P. Felt, F. L. Washburn and R. I. Smith.

Spraying Operations.

It has been fully proved that in the work of combating injurious leaf-eating insects the use of arsenical poisons is one of the most effective methods, provided it is applied at the proper time, and weather conditions are suitable. The use of arsenate of lead in the fight against the gypsy and brown-tail moths has been very helpful, and especially during the last season, as it was



HIGH-POWER SPRAYER IN OPERATION IN WOODLANDS.

very dry and possible to spray nearly every day during the caterpillar season. In purchasing arsenate of lead, care should be taken to buy from reliable dealers who are willing to guarantee their goods.

The improvement in spraying apparatus has been very noticeable, and better results have been obtained at a much less cost than heretofore. It has been the experience of this office that in woodland spraying it is necessary that the engine be at least 7 horse power, and that the pump deliver not less than 35 gallons per minute at 225 pounds pressure, thus allowing long lines of hose to be run from the machine, at the same time maintaining sufficient pressure at the nozzle. In woodland spraying it is advisable to move the machine as little as possible, and to keep it near the water supply. This may be done by using plenty of hose, and it lessens the expense of spraying. At the present time there are several good power outfits on the market that are suitable for doing woodland, street or orchard work. They vary in price from $700 to $1,000, and a large area can be covered in a day by any one of them. The average 7 to 10 horse power sprayer, under ordinary conditions, should cover at least 12 acres of woodland per day. In purchasing these machines they should be looked over very carefully, so that when delivery is made there will be no disappointment in the machine; and when starting the machine in operation in the field a competent engineer should be secured, who understands gasolene engines, as delays in the field, with the gang of men ordinarily used on large machines, are very expensive. Arrangements should be made when purchasing a machine to have the necessary assistance in starting the same. Great care should also be used in filling the tanks to see that no foreign matter is pumped up from the brooks or ponds, which may injure the pump. This may be avoided by having a box made 18 inches square and 30 inches deep, to be placed in the water supply. Bore holes in the box, and cover them with wire gauze on both sides and bottom. Under ordinary conditions, this box will allow enough water to flow in to supply the pump. Good judgment should be used in apportioning the amount of arsenate of lead, because at times, especially in the early spring, 10 pounds to 100 gallons of water will accomplish as good results as 15 pounds, and if the larger quantity is used it is simply a waste of money. There is no method used in fighting the moths where money can be wasted as easily as in spraying, especially with large machines, if care and judgment are not used. Care should be taken to order the necessary supplies for spraying before the season opens, so that when the foliage appears the machine can be put in operation in the field at once. Of course it is a well-known fact that early spraying, as soon as the foliage is large enough to hold the spray, is sure to be the most effective, as the caterpillars are then small and most susceptible to the poison. In several towns where the infestation warranted the use of a large machine it was somewhat doubtful whether such a machine could be used, on account of its weight. We have had several cases cited where it was impossible for two horses to draw the machine when loaded. The large area covered by these machines must be taken into consideration, and if an extra pair of horses should be used half the time during the spraying season, the additional cost would not amount to more than $75. It may also be expensive to get water if the town does not have hydrant service; but this is very easily overcome by the man in charge exercising good judgment, and building his roads so that he may locate the machine as often as possible near water supplies.

Another important matter to consider in using large apparatus is the hose. Where long lines are used it necessarily involves considerable expense, and proper care should be taken of the hose, in order that it may last as long as possible. It has been our experience that woven marline-covered hose is more economical than ordinary rubber or cotton hose, as it does not kink easily, thus avoiding breaks. It is also necessary that long-tailed two-bead couplings be used, so that they will not blow out under high pressure. Where woodland spraying is to be done, it is economy to purchase 1,000 feet of lead hose and 100 feet of suction hose. Brass fire nozzles with extra interchangeable tips, one ¼ inch and one 3/16 inch, are generally used.

A greater number of power sprayers will be in operation in the field the coming season than the past. In all probability there will be fifty new large machines engaged in the work, and with the good work accomplished by this new apparatus it is believed that better results will be obtained, and next fall, when the egg clusters are laid, they will be very few as compared with last season. We have several trained men accustomed to using power sprayers, and it is our intention to give all the assistance possible to the several cities and towns which have not had experience in the use of them. If the start is made in the right direction, much better results will be obtained.

It must also be taken into consideration that in cities and towns where small infestations occur, good results may be obtained by hand-spraying outfits. These outfits can be purchased at very moderate prices. One large enough to care for a few infestations costs approximately $27. This includes everything but hose. The next larger size, at $45, will give much better results in proportion to the cost. It must be remembered that only a few years ago hand outfits did the major part of the spraying against leaf-eating insects. Persons owning large orchards in towns infested by the gypsy and browntail moths obtain excellent results by spraying their fruit trees with arsenate of lead, using the small outfit, and this work has been greatly appreciated by those engaged in the work against the moths. In some of the smaller towns, having scattered infestations, small outfits were purchased by the towns, and citizens allowed to use them, furnishing their own poison. This has proved to be a great help both to the town and this office, and more of this work might be done to good advantage.

North Shore Work.

In 1907 the work of making a thorough inspection of the north shore woodlands was begun, and continued through the winter and spring into 1908. The block of woodland under consideration lies in the cities of Beverly and Gloucester, and the towns of Wenham, Hamilton, Essex and Manchester. When this work was finished, in March, a statement of the infestations located was drawn up and submitted to Col. W. D. Sohier, Beverly, Mass., who represented the residents of the north shore district. From him we received assurances that if a general effort to control the gypsy moth throughout this entire block of woodland, without reference to town boundaries, could be made, a substantial contribution from the property owners in that district would be forthcoming. After several conferences, with the approval of His Excellency the Governor, an agreement was made whereby this office, from its appropriation, the town of Manchester and the city of Beverly and the north shore residents, would all contribute to a fund to be deposited with the Honorable State Treasurer. It was also arranged that the expenditure from this fund for the purpose of suppressing the gypsy moth in the north shore woods should be under the direct supervision of this office. The total amount thus expended, and the sources from which it was obtained, are given in a financial statement on another page. This arrangement seemed most desirable, for many reasons. There is no more valuable area of woodland in the entire State or in New England than that which lies between Beverly and Gloucester. Here large sums of money — often running into the thousands on a single estate — have been annually expended by property owners to protect their trees from the moths. As long as adjoining woodland areas were not freed from the moths, the work of such public-spirited citizens was annually undone by caterpillars swarming in from without. Again, the residents of this section have built many miles of excellent wood roads for carriage driving, and thrown them open to the public. This section being so much frequented for shore driving, the danger here of spreading the moths through the dropping of caterpillars on vehicles is particularly great. Furthermore, it seemed particularly to the advantage of this office to co-operate liberally with these municipalities and citizens, when they were in the mood to make large contributions for the purpose of controlling the moths.

We treated the scattering infestations and began thinning operations in the woodlands on March 19, with 25 men, gradually increasing this number, until on May 10, 420 men were employed in the work. About 20 bad colonies had been located by the scouts where thinning operations were necessary, covering an area of approximately 1,100 acres. These colonies were freed from underbrush and dead trees, leaving the greater part of the conifers standing. Some gypsy moth egg clusters were treated in the worst infestations, and dead wood removed from trees where it seemed necessary. As soon as the foliage appeared, the thinning of woodlands was gradually stopped, since it was apparent that a larger area had been opened up for spraying than could be taken care of by the sprayers before the height of the caterpillar season. It was evident at the start that the principal reliance in treating these woodlands must be placed upon spraying operations; therefore, four power sprayers of the largest type were ordered early in the season, and were delivered and in operation during the week of May 17. In order to reach the most important colonies, and to make use of brooks, ponds or hydrants for water supply, it was necessary to construct more than 9 miles of wood roads. Many miles more would have been necessary if it had not been for the fact that with the high-power sprayers long lines of hose (1,000 to 1,500 feet) could be used with good results. At the same time, locations where water could be secured were taken into consideration. These roads are of permanent value for spraying operations at any time in the future.

Owing to the lateness of the season when this work began, and because of the millions of egg clusters present in the infested woods, considerable stripping occurred in the center of the worst colonies, and the insects migrated towards the borders of these colonies. This of course necessitated spraying the borders of the colonies, in order to destroy the migrating caterpillars. In nearly all places treated good results were obtained, and these colonies can be treated the coming year at a much less expense. If the necessary funds are made available the coming season, the woodland in which work has been done should come through the caterpillar season practically unharmed. At the close of the spraying season the force was reduced to a very small number of men. Some of them were engaged in putting the machines in order that they might be in good condition for the next spraying season, while the others were engaged in locating colonies which had become established in localities where we were unable to do any scouting. The development of this work showed that a second area as large as that first scouted was badly infested, and that it would be necessary to take up work along the same lines in this new section the coming season. After the caterpillar season the few men retained were engaged in creosoting egg clusters in some of the worst colonies.

The latter part of October a report of our work was submitted to Col. W. D. Sohier, and a further plan of co-operation, with the approval of His Excellency the Governor, was arranged between the residents of the north shore and the Commonwealth, and in the middle of December a force of about 60 men started thinning operations. After inspection, it became evident that a large sum of money would be necessary to continue this work. If the necessary amount cannot be made available, the woodland mentioned above as cleared and sprayed last year will suffer greatly, as well as the residential section in the district; and it is hoped that hearty co-operation can be obtained through the same channels as last year. We submit below a financial statement: —

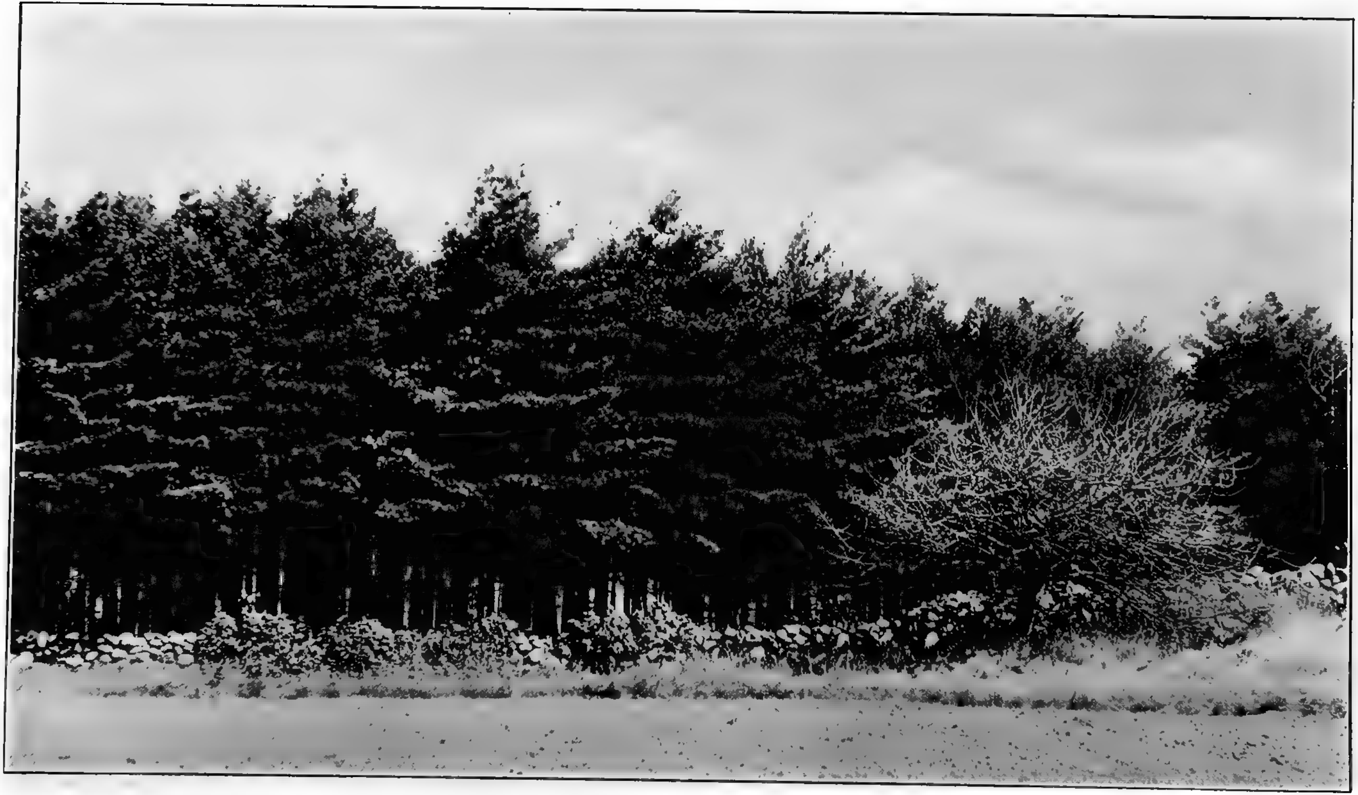
SPECIAL NORTH SHORE FUND.

Dr.

1908.				
April	3.	To Wm. D. Sohier, agent, . .	$2,000 00	
"	7.	To city of Beverly, ...	5,000 00	
"	10.	To A. H. Kirkland, superintendent, ...	10,000 00	
"	15.	To Wm. D. Sohier, agent, . .	3,000 00	
"	25.	To Wm. D. Sohier, agent, . .	5,000 00	
"	26.	To town of Manchester, . .	2,000 00	
May	19.	To town of Manchester, . .	3,000 00	
June	3.	To Wm. D. Sohier, agent, . .	5,000 00	
"	11.	To A. H. Kirkland, superintendent, ...	5,000 00	
"	26.	To Wm. D. Sohier, agent, . .	2,000 00	
July	7.	To Wm. D. Sohier, agent, . .	3,000 00	
"	9.	To A. H. Kirkland, superintendent, ...	5,000 00	
				$50,000 00

Cr.

By expenditures: —		
Wages of employees, ...	$38,393 60	
Travelling expenses, ...	250 38	
Rent, ...	60 00	
Supplies, ...	10,900 88	
Sundries, ...	324 90	
		49,929 76
Balance Nov. 30, 1908, ...		$70 24



PIERCE'S PINES, ARLINGTON, SHOWING RESULTS OF USE OF TANGLEFOOT ON WHITE PINE.

The Gypsy Moth v. White Pine.

In the last report of this department (page 163) this subject was discussed in a conservative manner, and details were given of a certain number of experiments with young gypsy moth caterpillars on white pine foliage, tending to show that in the early stages of their existence these insects could not live on white pine alone. Because of the importance of this discovery, if true, Mr. Kirkland preferred to take conservative ground, and await the results of the larger series of experiments in 1908. Fortunately for the thorough testing of the matter, there was found in the fall of 1907, at Arlington, Mass., on the property of Mr. F. A. Pierce, an area of 10 acres of white pine free from deciduous growth which was generally infested by the gypsy moth, some of the trees bearing hundreds of egg clusters. In co-operation with Mr. D. M. Rogers, Field Agent of the United States Department of Agriculture, these trees were banded early in the spring with the sticky preparation known as tanglefoot. Upon the hatching of the eggs the young caterpillars spun downward in large numbers to the ground, or died in the foliage of the trees. The bands, which were kept fresh for a period of about ten days, prevented their ascent, and, although the tree tops were literally full of the young insects, not a single pine was defoliated, and at the time of the fall inspection only 14 new egg clusters could be found in the entire area. The accompanying photographs, taken at the height of the caterpillar season, show the effectiveness of this method of treatment. This experiment on a large scale seems to give final and conclusive proof that where the hardwood growth is thoroughly destroyed in a pine forest, there need be no fear from damage by the gypsy moth caterpillars, provided the trees are properly protected from invasion from without by the use of sticky bands.

At Beverly, Mass., in the center of a large wooded area, about 3 acres of large white pines were found badly infested by the gypsy moth during the winter of 1907–08. Here all hardwood growth and brush were removed, and a limited protective belt cut around the pines. No further care was given to this colony. No egg clusters were treated or spraying done, yet notwithstanding the fact that in the spring of 1908 many of the large pines were literally yellow in places with the egg clusters, a careful examination in the fall of the year showed that, although the egg clusters had hatched freely, fresh egg clusters were exceedingly rare. There had been a decrease of the insect in this section estimated by Mr. Kirkland and the writer at fully 90 per cent.

Again, in a woodland colony at Marshfield — a generally infested section — all white pine was similarly treated, the hardwood and underbrush being removed, but no effort made to destroy the egg clusters on the pines. This colony received no further care during the summer, yet at the close of the year but three new egg clusters were found.

Considering the results of wholesale field experiments, together with those from the more carefully conducted investigations of the previous year, we are led almost irresistibly to the conclusion that a grove of white pine is absolutely safe from damage by the gypsy moth caterpillars as long as its borders are properly protected from invasion from without. It will be perfectly safe, as far as the gypsy moth is concerned, to make plantings of white pine, provided a belt of at least 200 feet in width is kept clear around the borders of the same. It will also be perfectly safe to leave standing in the moth-infested district blocks of white pine trees, provided all hardwood and underbrush are removed and kept down and the borders similarly protected. This may be done either by cutting clean belts around the blocks of pine, or by banding the trees with sticky materials for a distance, say, of 100 feet around the borders. We believe the results of this investigation to be of the greatest practical importance to those engaged in forestry operations in this State or elsewhere in the gypsy-moth-infested district, since it will permit of the general planting and cultivation of white pine without fear of damage from the moths.

Danger to Live Stock.

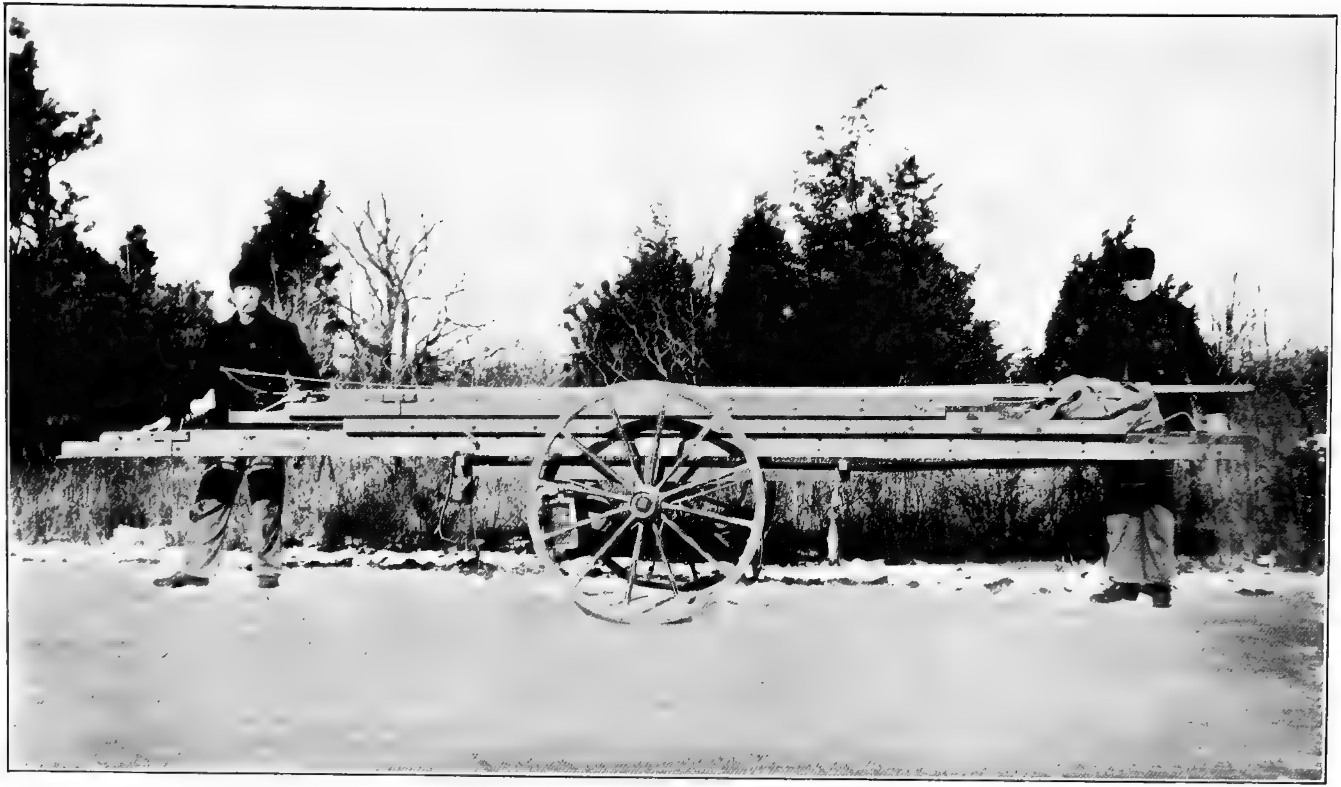
The experience of the past year substantiates that of 1907, and confirms our opinion that where the solid stream spray from high-power outfits is used there is a certain amount of danger to live stock which may later feed beneath the sprayed trees. With this system of spraying, which does not involve the climbing of trees, a large percentage of the poison falls to the ground. With the mist spray, used in connection with low-power outfits, where the trees are climbed and carefully sprayed by hand, but little of the poison falls to the ground, and there is practically no danger to live stock, other than poultry, which may feed under the trees. Since the wholesale spraying operations against the gypsy moth, particularly in woodlands and along roadsides, involve the use of high-power sprayers throwing a solid stream, much greater care must be taken in the future than in the past, to prevent the poisoning of live stock. We recommend that wherever spraying of this kind is done along roadsides, in pastures or in woodlands, suitable placards should be displayed, indicating that the trees have been sprayed and that it is dangerous for stock to be allowed to feed beneath them. The owners of land thus sprayed should be promptly notified. We think it also desirable, as far as possible, to fence off the sprayed sections from the unsprayed, as in the case of pastures, making such arrangements with the owners as may be necessary.

In the case of the alleged death of live stock from spraying operations, it is important that the viscera should be removed and subjected to chemical analysis, if claim for damages is to be made against the city or town. The Honorable Auditor of the Commonwealth has ruled that claims for loss from the death of live stock alleged to be due to spraying operations, under the direction of this office, are not a proper subject for reimbursement from the appropriations for the suppression of the gypsy and brown-tail moths, but that rather they fall in the class of consequential damages, which must be borne, if at all, by the city or town in which they occur.

Purchase of Supplies.

Further efforts have been made to systematize the purchase of supplies used by the several cities and towns in the work of suppressing the moths. It is of course most unbusinesslike that one town should pay a price greatly in advance of that paid by a neighboring town for the same kind and grade of materials. Last year competitive bids on the principal supplies used in the work were obtained from several dealers, and the lowest responsible bidder was recommended as the source from which goods of certain kinds should be purchased. This year a similar course has been followed on a more extended scale. During the fall months a complete list of all supplies needed in the field work was prepared and widely circulated among reputable dealers, who were invited to submit quotations, with the understanding that the lowest responsible bidder on a given kind of material should be recommended to the several cities and towns. A complete list has been made up from the bids so collected, printed in convenient form for the pocket, and supplied to each local superintendent. We have been able to secure considerable concessions on nearly all the important tools and supplies used in the field work. Thus an important economy has been effected, and the local superintendent has continually at hand the prices of supplies and addresses of dealers from whom such supplies can be obtained. It is urged that cities and towns follow the recommendations made in this list, in order to encourage the dealers to make even greater concessions in the future. The principal cost in the moth work is in the labor item, and every possible economy secured in other lines makes possible the employment of additional labor.

The local superintendent should, when purchasing supplies, keep in mind at all times the importance of buying supplies in as large quantities as he can use, so that the field operations may not suffer from lack of the tools at the right moment. Much better prices can be obtained, also, on larger quantities. In vouchers submitted to this office it has been noted in several cases that axes, bush hooks, etc., have been purchased one at a time. We advise that in most cities and towns at least one-half dozen if not more of such articles should be bought at one time, thus securing a supply on hand and enabling the local superintendent to spend most of his time with his men. We consider it good judgment at the opening of the several seasons to have the necessary supplies on hand to work with. It will be noted in the latest price list that hand carts are quoted. It is hoped that those engaged in the work will appreciate the saving that can be made by using one, thus doing away with the use of a horse and wagon as much as possible. In several



HAND CART RECOMMENDED TO REPLACE HORSE AND WAGON IN FIELD WORK.

cities and towns we believe that teams are being used more than is necessary, and we shall endeavor in the future to reduce this expenditure.

THE WILT DISEASE OF THE GYPSY MOTH.

During the caterpillar season of 1908 we employed experts to investigate the wilt disease of the gypsy moth, looking to the end that this disease, which is probably bacterial, might be propagated and spread artificially. No conclusions definite enough for publication were reached last season. The work will probably be continued in the summer of 1909.

THE FUNGOUS DISEASE OF THE BROWN-TAIL MOTH.

The experiments made under the auspices of this office during the past year for the purpose of testing the efficiency of the brown-tail moth fungus (*Entomophthora Aulicæ* Reich.) as a means of producing artificially a wholesale destruction of these insects in badly infested areas, was suggested by the apparent success of a similar experiment made during the previous year at Kittery Point, Me. Early in June, 1907, a large arctian larva was found in this locality, freshly killed by the *Entomophthora,* and as soon as the spore-discharge had commenced, several thousand brown-tail larvæ were placed in such a position that they would be exposed to it. The infected larvæ were then distributed over an area badly infested by brown-tail moths, and allowed to crawl up such trees as were most seriously infested, in order that they might join and mingle with the uninfected larvæ. The period of incubation of this disease is about five or six days, more or less, the time varying with the size of the infected individual, the temperature and the weather conditions; and after this period of incubation within the larva the disease is propagated by an external discharge of minute spores, which, by a special mechanism, are shot violently into the air. A well-grown larva, under favorable conditions, would probably discharge several hundred thousand of these spores, each capable of infecting a fresh larva in case it came in contact with one; and among gregarious insects, like the ones in question, the chances of copious infection are very great.

After a little over two weeks, that is, after time enough had elapsed for two or three generations following the death of the larvæ originally distributed, the locality at Kittery Point was again inspected, and a very general epidemic was found to be in progress. Thousands of the dead and dying larvæ were found on the trunks and branches of the trees, and everywhere that the brown-tails were feeding; and, when, somewhat later, the time for pupation had arrived, it was difficult to find a single healthy larva. It was further noticed that the disease had extended north and east in the path of the winds prevalent at this season, while there appeared to be little if any extension of the disease in the opposite directions.

Although the conditions indicated may well have arisen as the result of natural infection, and may not have been caused, or even greatly influenced, by the distribution of the infected larvæ, the extraordinary efficacy of the disease in clearing this region of the pest was not to be questioned. In view of the unusual susceptibility to the *Entomophthora* contagion shown by the brown-tail caterpillar, and the wide-spread epidemics to which it is subject from this cause, as evidenced by the conditions seen at Kittery Point, as well as in some other localities, it seemed desirable to certain persons interested in the endeavor to control this pest that some attempt should be made to test the efficacy of artificial infections with this fungous disease. By a special arrangement with this office, therefore, Dr. G. P. Clinton, mycologist of the Connecticut Agricultural Experiment Station, was given leave of absence for several months, in order that he might undertake the work. That the results obtained were less definite than had been hoped for was certainly not due to any lack of ability or persistent effort on the part of Dr. Clinton, to whom those especially interested in the experiment are under great obligation for the vigor with which he prosecuted the work, which was not only an interference with his professional duties at the station, but which was also accompanied by an amount of physical discomfort which can only be appreciated by one who has experienced the consequences inevitably associated with continual handling of these stinging caterpillars.

Owing to unavoidable delays in making the necessary arrangements with Dr. Clinton, the work on the brown-tail moth fungus, for which facilities were furnished by the botanic garden and the cryptogamic laboratories of Harvard University, was not commenced until May 14, and material of the fungus itself was not obtained until some days later.

Provision had been made for obtaining material of the fungus for use in artificial infections, by sowing resting spores, by means of which it is carried over in nature from season to season, in a breeding cage at the garden; but before any diseased larvæ appeared in this cage, several were found ready to discharge spores on nests brought into the laboratory. By means of these and others which in a few days began to appear in the garden cage, a sufficient number of infected larvæ was obtained to enable Dr. Clinton to make a first distribution in a badly infested tract at Concord. It was therefore not until May 28 that a first distribution of infected larvæ was possible; but even at this date it had become evident that the chances of a successful termination of the experiment were small, owing to the fact that the hot weather in May had advanced the season, as compared with that of the previous year, nearly two weeks, so that by the first week in June the larvæ were nearly ready to pupate, and a sufficient number of generations of the fungus between the first artificial infection and the period of general pupation was not available; while the drought which began in early June made the conditions as unfavorable as possible for the purpose in view. It was further found that in all the localities which were selected for the distribution of artificially infected caterpillars the disease had begun to appear spontaneously, so that such results as were obtained cannot be definitely attributed to the artificial infections made in these situations.

The mortality observed among the brown-tail moths, though very considerable (estimated by Dr. Clinton as from 10 to 80 per cent. in the various localities examined, with an estimated average of from 30 to 50 per cent.), was checked so abruptly by the dry conditions above mentioned, which began during the second week of June, that many larvæ were found later in the month that had been killed and mummified by the fungus, although, from lack of moisture, no discharge of spores from them had taken place, — a condition of things quite unusual where well-grown larvæ are concerned.

The results of Dr. Clinton's work have led him to express the opinion, in the report which he has submitted, that the outlook for a practical application of the fungous disease of the brown-tail moth by means of the distribution of infected material is an unfavorable one; but it should be remembered that his work was hampered and its successful accomplishment interfered with, first, by the fact that the work was begun three weeks later than it should have been; that the fungus was not available for use until it had already begun to appear in nature; that, the season being nearly two weeks earlier than on the preceding year, two or three generations of the fungus were eliminated from the experiment; and lastly, that the unusual dryness of the season afforded the most unfavorable conditions possible for the successful issue of the experiment.

Dr. Clinton was assisted in his work by Mr. A. T. Speare, now a graduate student in botany in Harvard University, who has subsequently been employed by this office to keep the fungus in an active condition by continuous propagation during the late summer, fall and winter, so that it may be available for use as early as may be necessary during the coming spring. This object has been successfully accomplished by Mr. Speare, who has the fungus in good condition for propagation in the greenhouses of the botanic garden at the present writing. It will therefore be possible, if it seems desirable to continue the experiment another year, to make the infections two or three weeks earlier than was possible during the past year, and before the fungus would occur in nature.

It may be mentioned further that Mr. Speare, despite the well-remembered drought of last August and September, made a successful attempt to spread the disease among the fall nests in a badly infested locality near Lynn, where he produced a destructive local epidemic not observable in adjacent localities; and it is also of interest to note that he succeeded, later, in finding larvæ containing resting spores in many of the infected nests, — a fact which indicates that under favorable conditions an infection of autumn nests may be depended upon to propagate the disease in the following spring.

In conclusion, the present situation may be briefly stated thus: The fungous disease of the brown-tail moth is undoubtedly the most efficient factor at present working in nature against the ravages of this pest, and under favorable conditions may almost completely eliminate it from considerable areas in a single season. In view of this fact, notwithstanding the unsatisfactory results of the experiments made during the past year, a continuance of the work for another season seems decidedly desirable, for the reason that a second attempt in this direction is not likely to be hampered, as in the first instance, either by lack of material for early infection, or by such delays in beginning the work as were incident to the first attempt; while, if the season proves neither unusually early nor unusually dry, much more favorable results may be anticipated.

The Parasite Work.

The work of importing and colonizing the various foreign insects parasitic or predatory upon the gypsy and brown-tail moths has been continued throughout the year. The material imported, while in actual amount not greatly in excess of that of the previous years since the work was begun, has generally been received in better condition and has been more diverse in character. The actual number of beneficial insects liberated was far in excess of that for 1906 or 1907, and the list includes several of great importance and promise which have never before been received at the laboratory in a living condition, or at all.

This increase is due to several causes. The improved condition of the foreign material on receipt and its greater diversity in character are in part responsible. The laboratory at Melrose Highlands is much better adapted for the work than was that at Saugus; the permanent force at the laboratory has been notably increased; and, more than all, a larger knowledge of the parasites and predators themselves, their habits and requirements, has made possible a much more intelligent handling of the imported material.

Mr. W. F. Fiske, who assumed charge of the laboratory work in 1907, has continued in that position throughout the year, and has been most ably assisted in the actual work of colonization and in the subsequent work in the colonies by Mr. F. H. Mosher, who has been connected with the laboratory since its inception. Mr. A. F. Burgess, who has been connected with the work against the gypsy moth upon several occasions in the past, was detailed by the Federal Bureau of Entomology to work upon the several species of predaceous beetles; and Mr. C. H. T. Townsend, who has wide experience and national reputation in his particular line, was similarly detailed in charge of the Tachinid parasites.

This division of the laboratory work has made possible a much more thorough investigation into the habits and biology of the insects studied. While this work has of necessity been more or less technical, in part, it has been the aim of those concerned to eliminate all purely technical features, and to confine the investigations to those phases in the life of the insects which were in some way associated with the actual and practical work of importing and liberation under conditions which should be as favorable as could possibly be secured.

Importations have been received from all of the central European countries, as hitherto, and in addition a large amount of material was secured from Japan, through the efforts of Prof. Trevor Kincaid of the University of Washington, Seattle, who spent the entire season in Japan as an agent of the Commonwealth. It was through him that the enormous numbers of cocoons of the Japanese *Glyptapanteles* were received. This insect has long been known as one of the most important of the natural enemies of the gypsy moth in Japan, and each year since the parasite work was begun attempts have been made to secure it; but invariably the parasites have been dead upon receipt, and it became evident that it was necessary to employ especial care in the collection and packing of the material and shipment in cold storage before success could be expected.

This most difficult task was most ably accomplished by Professor Kincaid, who made satisfactory arrangements with the steamship companies, devised a package by the aid of which not only the parasite cocoons themselves, but the young parasitized caterpillars of the gypsy moth itself, were shipped successfully. In addition to this, his industry in collecting the vast amount of material, in which he was fortunate enough to secure the active co-operation of the native entomologists, is noteworthy.

In addition to the *Glyptapanteles,* which is considered as the most important of the Japanese parasites, several other species, less important according to our present standards, but promising, nevertheless, were received through Professor Kincaid. These include Tachinids of several species, for the most part similar to European forms; several Hymenopterous parasites of the pupæ, and a number of egg parasites, a part of which have since been received in considerable numbers through Japanese entomologists, and are now being held at the laboratory for liberation in the spring.

The work upon predaceous beetles has been in some respects the most satisfactory of any done at the laboratory. In 1906 and again in 1907 considerable numbers of the most promising of these, *Calosoma sycophanta,* were imported as adults, and liberated in several localities in eastern Massachusetts. In 1907 the beetles were found in nearly all of the localities where liberations were made the previous season, and in 1908 they were again found in these colonies, and also in the colonies established in 1907. In most instances they were present in numbers sufficient to denote a most satisfactory rate of increase.

Beginning in the fall of 1907 and continuing through 1908, several other beetles, less promising, but of possible assistance in controlling the gypsy moth, were imported in smaller numbers and studied at the laboratory or liberated directly in the field. A considerable number of adults of the *Calosoma* above mentioned were kept under as natural conditions as possible in the laboratory, and from them a large number of larvæ were reared through their early stages and then liberated in the open. Serious losses, which are likely to occur among the very young larvæ in the field, were thereby avoided, and the increase and rapidity of dissemination of the insect hastened.

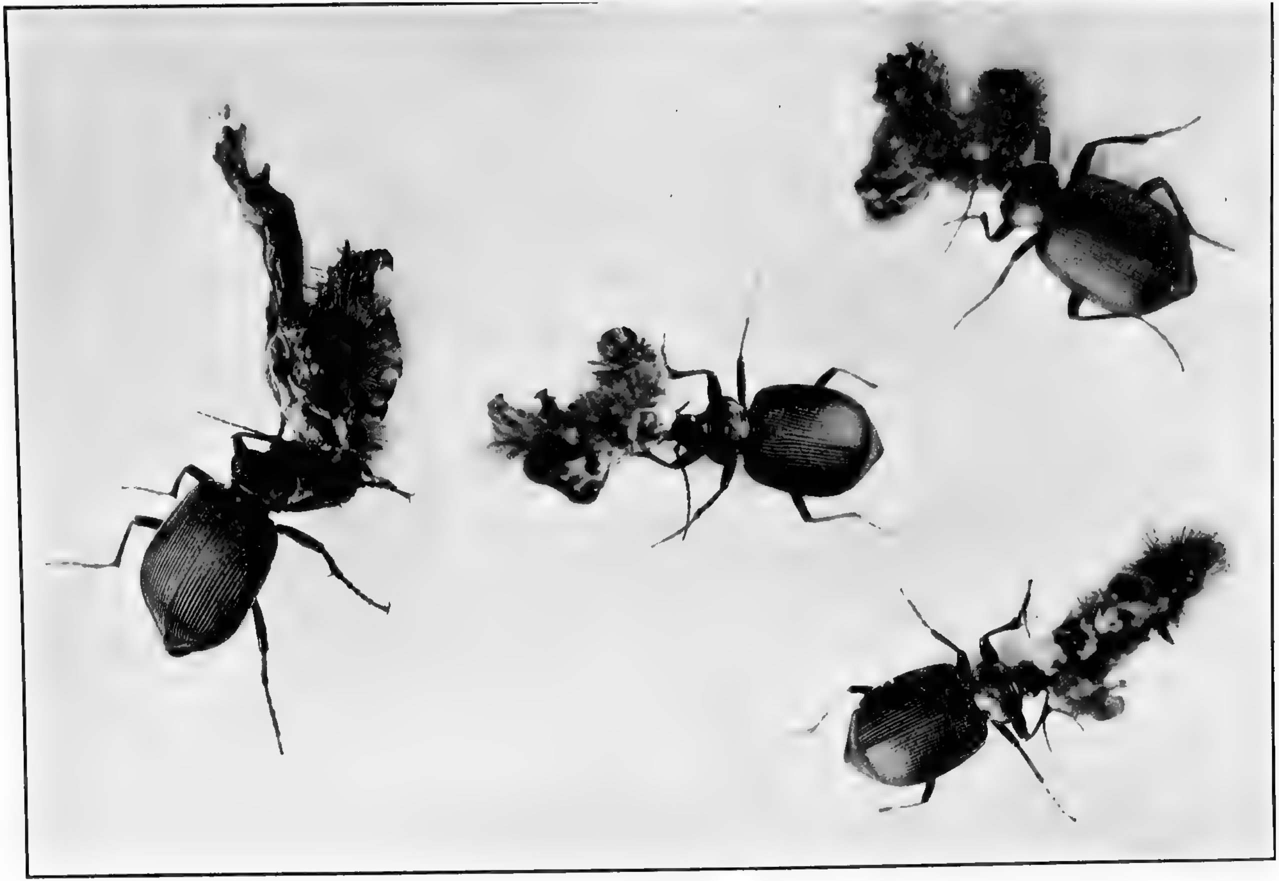
So common did this enemy become in certain of the localities where it had been liberated, as to make it advisable during the summer to issue a brief bulletin, illustrating the different stages, as a warning to those engaged in the destruction of the gypsy caterpillars and pupæ. The full-fed *Calosoma* larvæ frequently take refuge under the burlap bands, and any one ignorant of their nature might inadvertently destroy them.

Although this insect is unlikely ever to increase in numbers sufficient to control the gypsy moth unaided, yet it possesses several most promising characteristics. Its various stages are well represented on Plate 12. The eggs are deposited in the earth near the base of trees infested by the caterpillars, which serve as food for both larvæ and adults. The larvæ as soon as they hatch climb the trees in search of their prey, and even at this stage are strong and active enough to attack the full-grown caterpillars of the gypsy moth. When supplied with an abundance of food they grow rapidly, molting twice, and then enter the earth, where their subsequent transformations to pupæ and adults occur. The adults do not appear to leave the earthen cell in which the final transformation takes place until the following spring, when they come forth, ready and willing to begin their warfare upon the young gypsy caterpillars without delay.

They are known to live for several years; and during their periods of activity, which correspond in a general way to those of the gypsy moth itself, they feed voraciously, and during these periods the females lay in the aggregate a large number of eggs. They appear to seek out and to remain in the vicinity of the more abundant colonies of their preferred food; and the fecundity of the females, and the consequent rate of increase of the species, is to some extent, at least, dependent upon the abundance of the food supply.

The increase and particularly the dissemination of this insect may be hastened materially by artificial means, and during the next few years it is desired to do everything possible which will favor its spread and multiplication. At the very best, however, it will require several years before it is possible for it to demonstrate its value from an economic standpoint, notwithstanding the abundant evidence of its beneficial character already secured.

The Tachinid or Dipterous parasites of the gypsy and brown-tail moths include a large variety of species of more or less promise. Some of these occur so infrequently abroad as to



CALOSOMA SYCOPHANTA BEETLES ATTACKING GYPSY MOTH CATERPILLARS.

make their utility in this country very problematical, but there are a few among them which are of greater promise than any others among the numerous natural enemies which have been studied at the laboratory.

The work done by Mr. Townsend has demonstrated the existence of a very great diversity in the life of these insects during their earliest stages; and the results of this work have served not only to indicate the best methods by which the parasites themselves may be imported and handled after receipt, but have tended strongly to indicate the enormous possibilities for good possessed by certain among them.

Probably the most promising at the present time is one technically known as *Blepharipa scutellata,* a large and strong insect, not unlike the common fly in general appearance. The females of this species deposit several thousands of exceedingly minute eggs upon the foliage of trees near where the caterpillars of the preferred host are feeding. These eggs are eaten by the caterpillars, hatch in the alimentary canal, and the young maggots resulting, establish themselves within the tissues of their host. For a time they feed without causing it apparent inconvenience, but when nearly full fed, which may not be until after the caterpillar has changed to a pupa, they cause its death, feed for a time upon the dead body, and then, dropping to the earth, burrow into it and complete their transformations.

The perfect flies do not emerge until the following spring, and there appears to be but a single annual generation, in which respect the parasite resembles the gypsy moth itself. An insect depositing its eggs upon a leaf, in the chance that this leaf will be eaten by an insect which is capable of nourishing its young, is exposed to a very great liability of loss during its egg stage. This is partially compensated for by the large number of eggs deposited, amounting, as has been stated in this instance, to several thousand, possibly 5,000 or more. It possesses at the same time a potential fecundity far in excess of that of the gypsy moth itself. When practical defoliation occurs, as it frequently does where the caterpillars are numerous, the increase of the parasites ought to be very rapid, and, other conditions being equal, far to outstrip that of the gypsy moth itself.

In spite of the relatively considerable abundance of this insect abroad, and of the fact that it has been received in considerable numbers each year since the work of parasite introduction was begun, it has been found impossible to procure enough healthy adults to form a colony of a size sufficient to form a fair test of its economic value as a parasite. This is due to the great difficulty in keeping the pupæ over winter, under the necessarily artificial conditions accompanying their collection and transportation. The maggots, after their emergence from the caterpillars, normally enter the ground to a considerable depth. Here they should remain undisturbed until their final transformation to the fly in the following spring; and it has been the experience at the laboratory that any disturbance to which they may be subjected during this period is followed by a rate of mortality amounting, in the several years since their introduction has been attempted, to from 90 to 98 per cent. The cause of this appalling death rate is not altogether apparent. It is hoped that it will be materially lessened in the case of the thousand or more pupæ now on hand; but should these hopes prove futile, it will be only a question of time and additional expense before a satisfactory colony of the insect is established.

In 1908 about 100 healthy individuals of this species were liberated near Melrose. The species was not recovered in the considerable collections made in the vicinity of the colony the same season; but the fact was not at all to be wondered at, from the relatively insignificant number of the parasites as compared with the many millions of gypsy moth caterpillars which were present in the area over which the parent flies would be expected to fly. There is, therefore, a possibility that the insect has already gained a foothold in America.

Blepharipa, while possessing more promise than the majority of the numerous species of Tachinids imported or attempted which have been secured in larger or smaller numbers, is only one of several scarcely less promising, and it is hoped that several others will successfully be introduced and acclimated in the course of the coming season. Several of these which have already been imported and colonized have also been recovered from collections made in the field. One of these, *Parexorista cheloniæ,* while entirely different from *Blepharipa* in habit during its early stages, is of considerable importance as an enemy of the brown-tail moth abroad, and likely to become so here.

The Hymenopterous parasites of the gypsy and brown-tail moths, while less numerous than the Dipterous, include several very important species very diverse in their habits. These insects are more adaptable to increase in the laboratory than are the Dipterous; and one in particular, which attacks the hibernating brown-tail caterpillars within their nest, has been reared in the laboratory by the hundreds of thousands, and at small expense. There are on hand at the present time, awaiting the proper time for their liberation, in excess of half a million of the young of this insect, the result of the increase from a few thousand which were kept on hand during the summer.

Another species, *Monodontomerus,* which attacks the freshly formed pupæ of the gypsy and brown-tail moths, and which hibernates as an adult within the winter nests of the last-named species, has shown a rate of increase and of spread under natural conditions in Massachusetts which is almost incredible. It has been secured from brown-tail moth nests in no less than six different and widely separated towns this winter, and, while the numbers present in each instance were small, the wide dissemination of this parasite means that an astonishing number are present in the aggregate.

One of the features of the work for 1908 was the rearing and liberating of more than 12,000 of a small species of *Apanteles* which attacks the brown-tail caterpillars in the fall, before they have entered their hibernating webs. The young parasite lives within these caterpillars, without causing them inconvenience, until after they have emerged from their webs and have fed for a period in the spring. At about the time when the healthy caterpillars pass their first spring molt the parasitized individuals die, and the parasite larva emerges and spins a cocoon similar in appearance to that of the Japanese parasite, but, unlike that species, always solitary. The handling and feeding of large numbers of caterpillars necessary to produce 12,000 of these adult parasites by means of any of the appliances for this purpose ordinarily in use in entomological laboratories was wholly impracticable, and made imperative some new device.

This was finally secured by a radical modification of the method used for the rearing of silk worms. Specially constructed trays were employed, from which the caterpillars were prevented from escaping by a band of "tangle-foot;" and complete success, so far as the laboratory end of the work was concerned, was secured. The successful establishment of the parasite could not be determined until the spring of 1909, under any circumstances, but it is confidently expected that it will be recovered from the vicinity of the colonies at that time.

It is desired during 1909 to continue the importation of parasitized caterpillars and pupæ of gypsy and brown-tail moths, as in the past, and to make especial efforts to secure considerable quantities of the living parasites of those species which it has been found impossible to secure living and in numbers heretofore. The work of importation has proved much more difficult than was anticipated. In certain respects the method of collecting and shipping the European material has proved to be inadequate, and while it permits of some among the numbers of parasites to reach their destination in safety, it is fatal to others among which are some of the most promising. To correct these faults it is hoped that arrangements may be made for the establishment of a shipping station in Russia, under the direction of Professor Kincaid, who has demonstrated his remarkable ability in this line during the past year in Japan. The selection of Russia as a site for the proposed operations has been made after a great deal of deliberation, and a full consideration of all of the advantages and disadvantages of such a selection. The problem of successful transportation of the parasites or of the parasitized caterpillars is great, and will require especial arrangements with the transportation companies and with the Russian government itself, in order to secure the celerity of dispatch which is absolutely necessary for success, and the avoidance of an examination of the packages at the frontier. These disadvantages are, in the opinion of those responsible for the selection, more than offset by the greater abundance at the present time of the gypsy moth and of its parasites in this section of Europe.

A trip made by Mr. Fiske in September, 1908, into southwestern France, where it was first intended to establish this station, indicated the unfitness of this section, since at the present time the gypsy moth is very rare there. It is necessary, for the success of the undertaking, that the material shall be packed properly during the early as well as the later stages of its transmission from the field to the laboratory. Without the skill displayed by Professor Kincaid in packing the material collected by him in Japan last season, the results of his trip would have been relatively insignificant.

The entire proposition of introducing the parasites of the gypsy moth is unique, even among other attempts which have been made along similar lines. The insect which it is desired to control differs so materially in habit from any which have been the subject of similar attempts in the past as to make it necessary to devise entirely new methods for handling its parasites, many of which are themselves different in habit and character from any hitherto handled. The fact that they may only be secured in connection with the gypsy or brown-tail moth caterpillars or pupæ makes it a question of success upon the first effort, or of delay for an entire year for a recurrence of the proper season.

The same is true of practically every phase of the work. It is rarely indeed that the success of an attempt at colonization of any species becomes apparent until a full year after the colony is planted; and failure cannot positively be determined until several years have elapsed, allowing for an increase in the abundance of the insect until its presence shall become apparent.

It is in this respect more than in any other that this undertaking differs so radically from the importation of such parasites as those of scale insects, for example, which pass through several generations annually, thus making the experience which has been gained by work upon such insects and their parasites of practically no value.

REPORT OF PROF. FILIPPO SILVESTRI OF THE ROYAL SCHOOL OF AGRICULTURE, PORTICI, ITALY.

In July of this year Prof. Filippo Silvestri of the Royal School of Agriculture at Portici came to this country, and by invitation of Superintendent Kirkland made a visit to the infested district around Boston and to our parasite laboratory at

Melrose Highlands. Superintendent Kirkland asked him to give us an expression of his opinion in regard to the methods used in carrying on the work, and also on the methods used in importing and breeding parasites, and he submitted to us the following report: —

NEW YORK, July 20, 1908.

To Mr. A. H. KIRKLAND.

I made a visit to your laboratory at Melrose Highlands, where the parasites of *Lymantria*[1] and *Euproctis*[1] received from Europe and Japan are developed. I have visited a large part of the surroundings of Boston where the war against these insects is carried on by artificial methods, and also the places where they have been allowed to spend all their activity. I have read the three annual reports of the work accomplished in 1905, 1906 and 1907, as you desired my full and frank opinion about the work which is being done under your direction, and also my opinion as to what seems likely to occur in the future, and I herewith make it with the greatest pleasure. I will begin by saying that the two insects mentioned above are a veritable pest of much importance on trees of North America, and that if left unmolested they will finally occupy almost all the temperate regions of North America, causing incalculable damage. *Lymantria* and *Euproctis* are insects introduced from Europe without their parasites; therefore here we do not find the natural check which in Europe in the case of many insects usually destroys them in such quantities that they are reduced to such small numbers as to be unnoticed. It is possible in Europe in some years also to have a serious enemy in special climatic conditions, which favor the development of infectious diseases caused by different bacteria and fungi; but these conditions are not under control, and naturally do not occur with much frequency, and, although they are of economic value, yet they cannot be relied upon to the extent of giving up artificial suppression. Nevertheless, I believe that it would be useful to have competent persons study the maladies to which *Lymantria* and *Euproctis* are subject in Europe and elsewhere, although only such persons as are competent to identify the same should be employed in the work.

The spirit manifested by the Congress of Massachusetts at the beginning of the work was excellent and extremely patriotic, inasmuch as they contemplated the complete extermination of *Lymantria* and *Euproctis* in America; but no entomologist of the present or of the future I believe will be able by any means to attain to complete extermination of an insect so scattered through woodlands and on various kinds of vegetation. Will it be possible in such a case to attain the complete suppression, and, if that is not possible, to fight these insects so that their numbers can be kept down so as to be unnoticed from an economic point of view? They are now known to be scattered over 3,140 square miles, notwithstanding that in America they have fought them with excellent methods; and it seems to me impossible, at least not probable, that an artificial warfare should be kept up against such insects all over the territory infested. Therefore, the fight ought to be continued as much as possible, as under your direction it has been started, especially along the roads, to prevent the carrying of larvæ on vehicles of every kind into the surrounding territory. Also, I think it is necessary that the infested area should be decreased as far as possible without observing the expense in such a case.

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[1] Generic names of the gypsy moth and the brown-tail moth.

In regard to the artificial suppressive measures used in fighting the gypsy and brown-tail moths, it seems to me that at the present none could be better than those used by you. Notwithstanding, therefore, all that the financial power of North America can accomplish in combating artificially these insects, I am convinced that they will not succeed by such means in preventing the invasion of other States in the future; and that, notwithstanding the enormous expense which is annually sustained by private individuals, municipalities, the State and the nation, there will always be great damage. Such being the hard facts, I am only able to give my praise, with that of the other eminent entomologists, to the one who first thought of introducing the parasites of the gypsy and the brown-tail moths from Europe and Japan to assist in the fight against them. I believe that to none other less capable than Prof. L. O. Howard should be confided the direction of this work of introducing and rearing the parasites of the two injurious lepidoptera, and I fully approve the methods followed in the shipment of the parasites from Europe and Japan, — a good method, which only experience and skill can improve. The methods which I have seen in practice at the laboratory at Melrose Highlands for the care of the parasites collected from Europe and Japan, and the methods used in the breeding of the same, appear to me good; also, the results already obtained in acclimatizing the *Calosoma sycophanta* are almost incredible. This insect is a beetle which is most active in Europe in all stages of larva and adult in destroying the larvæ of the gypsy moth, and there is much hope to be placed on the work of this first enemy now secured in this fight against the gypsy moth. I, for my part, do not doubt of the acclimatization in America of various species of parasites from the different orders of Hymenoptera and Diptera which have been and will be introduced; also, I have no doubt of their value in the fight against the gypsy moth, provided they are introduced without their secondary parasites. I have seen that at the laboratory at Melrose Highlands the greatest care is used in separating the primary from the secondary; but to lay particular stress on this part of the work on the parasites will not be superfluous, above all, that care should be taken to make sure of the true degree of worth of the parasites by study of the biology of the parasites of *Lymantria* and *Euproctis* in the country of their origin.

I believe it will be necessary to study the biology of all parasites that are at all known in parts of Europe and Japan, because I am convinced that the biological knowledge of these insects is the true base of economic entomology; and that in this special case, where you wish to make use of parasitic insects to fight another insect, it is indispensable to have a profound knowledge of their biology. Therefore, I believe that without doubt the biological study of the parasites of the two injurious species of Lepidoptera, in Europe, Japan, and possibly also in the Asiatic continent, ought to be entrusted to a competent person. After such study they will be able to determine surely the true rank of the parasites of various species of Hymenoptera, to kill all secondary parasites and to liberate instead only those which are of the first rank, and among these last, if possible, those only that are of special importance in combating *Lymantria* and *Euproctis.* In the study of the biology there will be brought to light many interesting facts, which will enable those engaged in the work to obtain a sure result, and in the shortest possible time. It seems to me also that it will be necessary to increase the number of entomologists who are occupying themselves with the biology of the parasites in Massachusetts, and that they should occupy a larger laboratory, where the sheds in which they work may be more dispersed, so that the temperature will not be too high, as it happens now in the large shed situated near the laboratory.

To protect as much as possible the parasites that are now introduced, it will be advisable to reserve for breeding places in the central part of the infested territory a certain number of localities some miles apart. Of such localities one should be for the *Calosoma sycophanta,* because, being a predatory insect, it should not be in the same place as the Hymenopterous parasites; and the other localities for the Hymenoptera and Diptera should be reserved as much as possible for the species of parasites of the various orders, so that each species should remain alone for some time to combat in a given locality the gypsy moth and the brown-tail moth. In the localities reserved for the action of the parasites artificial suppressive measures against the two Lepidoptera should not be carried on to extremes, but only such as are necessary to reduce the insects in numbers so that the trees surrounding shall not be defoliated, but so as always to leave a sufficient number for the parasites. Such partial artificial methods ought to be directed against the egg when there are plantings of the parasites which attack the larvæ and pupæ, and against the larvæ in turn when the parasites attack the eggs. By such methods I believe the best conditions possible for favoring the multiplication of the parasites in the field will be obtained, and the beneficial results from the introduction of the same parasites will be hastened.

In conclusion, I recommend the following: —

1. The artificial suppressive measures to be carried on with vigor wherever it is possible and convenient, except in the locality in the central part of the infested territory set apart for the multiplication of the parasites.

2. Vigorous suppressive measures along the streets and on the borders of the infested territory, in order to prevent as much as possible the extension of the area of infestation.

3. The study of the biology of the parasites in Europe and in Japan, in order to profit by such study in the introduction and rearing of parasites.

4. The continuation of the collection of parasites in Europe and in Japan, liberating the same in America in localities set apart for each species of parasites that are recognized surely to be of the first rank.

What will be the final result of this fight? I believe that the results will be the best, because as far as I can see it seems that there can be no obstacle in the way of acclimatizing in America some at least of the parasites of *Lymantria* and *Euproctis*, and that surely at the end of some years there will be a large number of parasites working against these insects. For some years, then, it will be well to continue the suppressive artificial methods, only being careful not to destroy the parasites (a thing that will be in part at least possible); and after the work is left to the parasites, the specimens of the gypsy and brown-tail moth will be reduced to a negligible number. It is well known that they still have in Europe serious infestations of these insects at intervals. This is because the parasites have in their turn other enemies, primarily among these other parasites. Here in America, if care is taken not to liberate the secondary parasites with the primary parasites, the gypsy moth and brown-tail moth will always have many enemies.

Also, if the final result of the introduction of the parasites should not be as happy as it is foreseen, nevertheless, it would be sufficient to accomplish by their means the result of combating efficiently enough the gypsy and brown-tail moths.

Therefore, I for my part felicitate you and Professor Howard for what you have done both in science and in practice, and so much the more that in the present case the national economy, whose prosperity stands highly to every citizen of the United States, is seriously concerned.

Perseverance, then, and confidence in this warfare, since I believe your success will be complete, at least if nature does not conceal some new and unexpected weapon of defense.

I thank you for the kind invitation to expound fully my opinion about the work under your direction, and with best wishes for your distinguished health, I am,

Yours most sincerely, FILIPPO SILVESTRI.

Report of Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, D. C.

United States Department of Agriculture,
Bureau of Entomology, Washington, D. C., Jan. 4, 1909.

Mr. L. H. Worthley, *Acting Superintendent for Suppression of Gypsy and Brown-tail Moths, 6 Beacon Street, Boston, Mass.*

Sir: — I have the honor to submit a brief report of my efforts during the period since I submitted my last report to you, on Jan. 20, 1908, to import the foreign parasites of the gypsy and brown-tail moths into Massachusetts.

Respectfully yours, L. O. Howard, *Chief of Bureau.*

At the time of writing my last report the active work of the season in this direction was practically completed. In the autumn the parasite laboratory was moved from Saugus, Mass., to Melrose Highlands, Mass. The new location is much more accessible to Boston and to most of the field colonies of the parasites. The buildings, including several substantial structures built for laboratory purposes by the State of Massachusetts, are much better fitted for the work. Upon the whole, the results of the year's importations have been very promising.

In planning the work several features have been introduced. The parasites that are constantly being sent over by agents belong to three main groups, namely, those of the order Hymenoptera, including the Ichneumon flies, the Chalcis flies, and others; those of the order Diptera, including the Tachina flies; and those of the order Coleoptera, including the predaceous ground beetles. The amount of material received has been so great, and the character of the different life histories of the insects involved has been so diverse, that it has seemed of great importance to have a thoroughly trained expert, skilled in the biology of each group, placed in charge of each group. This has been done, and one expert has had charge of the Hymenoptera, another of the Diptera and another of the Coleoptera. Further, the condition of European sendings by mail and by express during the summer of 1907 was by no means uniformly good. The sendings from eastern Europe, which are subject to long railway journeys, in addition to the sea voyage, frequently arrived in bad condition. Therefore, an innovation was made, and a general laboratory depot was established at Rennes, France, under the general supervision of Mr. René Oberthür, and a skilled assistant, Mr. A. Vuillet, was placed in specific charge. Nearly all of the European sendings were shipped to Rennes, were examined, repacked, carried personally by Mr. Vuillet to Cherbourg or to Havre on the known days of sailing of certain steamers, then placed in the hands of chief stewards of the vessels and carried in the cold room to New York, where they were admitted without examination and sent direct to Boston. This method has resulted in a much better average condition of the material received, and has facilitated the rapidity with which the work is being accomplished. The courtesy of the steamship officials is highly appreciated.

The third innovation has been an attempt to secure Japanese parasites of the gypsy moth. It has been known for some years that the true gypsy moth, or one of its varieties, or at least a most closely related species, occurs in Japan, though not in great numbers, and that it is apparently held in check by its parasites. Rev. H. Loomis, an American living in Yokohama, has repeatedly written to the State authorities of Massachusetts and to the United States Department of Agriculture, conveying this information; and attempts have been made by mail and otherwise to send these parasites to the United States, but without success. Later information, received from one of the most skilled economic entomologists of Japan, Mr. Nawa, indicated that there exists in Japan an important egg parasite of the gypsy moth. Remembering that the Massachusetts gypsy moth came originally from Europe, it seemed altogether desirable to introduce first the European parasites, and it seemed probable that these would by themselves re-establish the balance of nature. Then, too, the importation of the Japanese species seemed somewhat dangerous, on account of the chance that the Japanese gypsy moth might prove even more voracious and destructive than the European moth; but after mature consideration it was thought best to leave no stone unturned, and to neglect no chances in the search for effective parasites. The European service of collectors and agents and advisors had been well organized and instructed during three annual visits of the Chief of the Bureau to Europe; and it was therefore decided to interrupt the European trip for the present year, and to send an agent to Japan. Prof. Trevor Kincaid of the University of Washington, at Seattle, was chosen on account of his skill as a collector, evidenced in the remarkable results of the Harriman expedition to Alaska, his comparative proximity to Japan, and the fact that he is personally acquainted with many persons in Japan. He sailed on March 2, and the results of the expedition have more than justified the expense involved. A very large amount of parasitic material has been received from him in good condition at Boston, and very many parasites from Japan have been colonized in the woodlands of New England.

Still another decided innovation has been the carrying on of active winter work with parasites, especially those secured from imported nests of the brown-tail moth, which began to come in from Europe in December. It was found quite possible to breed these parasites in artificially heated rooms, feeding them upon hibernating native brown-tail moth larvæ brought in in their nests from out of doors, feeding the latter upon lettuce and other hothouse foliage, and in the early spring securing more normal food for them by sending it up in boxes by mail from Washington and points south. In this way the breeding of the parasites of the genus *Pteromalus* was carried forward uninterruptedly throughout the winter, and, as during the breeding of successive generations they multiplied exceedingly, it was possible later in the year to liberate a vastly greater number of individuals than would have been possible had the imported species been allowed to hibernate normally in the nests. In the course of this work Mr. W. F. Fiske, in charge of the breeding operations, has invented a rearing tray which has been of the utmost advantage, and which will greatly facilitate parasite rearing work in the future.

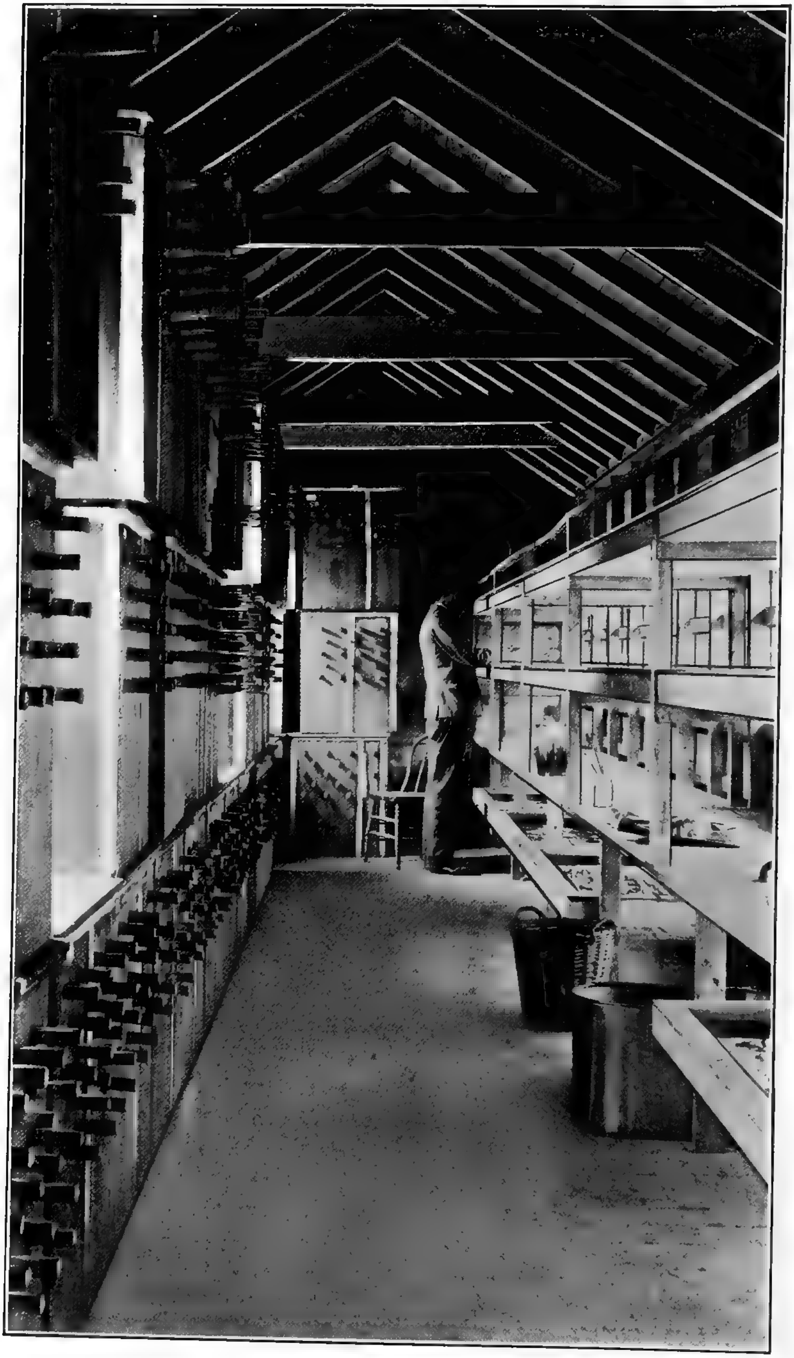
Still a fifth innovation, and one of great value, has been the discovery and practice of retarding the development of brown-tail moth eggs by keeping them in cold storage until the arrival of the European egg parasites, which will oviposit upon and breed in these cold-storage eggs as freely as in those which they attack in the state of nature. This process, it has been ascertained, may be carried on for a long time, and successive generations of these egg parasites may be reared from eggs retarded in their development by cold storage. It is thus easy to breed and to liberate an almost infinitely greater number of these egg parasites, and under favorable conditions, than would be possible from a simple importation of European parasitized eggs which would have to arrive in America at a specific time. These latter innovations have been due to the ingenuity of Mr. Fiske.

In the same way great advance has been made in the rearing of the Tachinid parasites, under the charge of Mr. C. H. T. Townsend, who has devised methods and made observations that have greatly added to our knowledge of the biology of these insects, and have resulted in the accumulation of a store of information of the greatest practical value not only in the prosecution of the present undertaking, but in any problem of parasite introduction or control that may arise later. Extraordinary and almost revolutionary discoveries have been made in the life histories of certain of these flies, and without this knowledge the greatest success in handling them practically could not have been reached.

Similarly, Mr. A. F. Burgess, in charge of the Coleoptera, has succeeded in a very perfect way in rearing and liberating the important European predatory beetle (*Calosoma sycophanta*), as well as some other insects of the same family.

Altogether, down to July 1, 1908, the following material was imported: —

Brown-tail moth egg masses, about 26,000.
Hibernating nests of the brown-tail moth, from 50,000 to 60,000.
Free larvæ and pupæ of the brown-tail moth, about 178,000.
Gypsy moth egg masses, 7 boxes, each containing very many masses.



BREEDING CAGES AND TRAYS FOR PARASITES OF THE BROWN-TAIL MOTH AT LABORATORY.

Gypsy moth larvæ and pupæ, about 161,000.

Gypsy moth larvæ from Japan, 8 large boxes, containing several thousand larvæ and parasite cocoons.

Predatory beetles, 2,892.

It will be noticed that only about half as many of the hibernating nests of the brown-tail moth were imported during the winter of 1907–08 as during the winter of 1906–07; but the smaller number is offset by the larger numbers of larvæ, pupæ and egg masses, so that the gross amount received is about the same as that of the previous year. The material received from Japan listed above came in before July 1, but in all there have been received about 40 boxes, nearly all of large size. From one shipment of the cocoons between 40,000 and 50,000 adults of one of the most important parasites of the genus *Glyptapanteles* were reared and were liberated directly in the open.

The colonization work has been going on rapidly during the summer of 1908, and of the species colonized the following have been the most numerous: —

Pteromalus from the brown-tail moth nests,	114,000
Trichogramma from the brown-tail moth eggs,	11,600
Telenomus from brown-tail moth eggs,	4,560
Apanteles of the brown-tail moth,	12,875
Japanese *Glyptapanteles,*	45,000
Meteorus from brown-tail moth,	1,080
Pimpla from brown-tail moth pupæ,	2,051
Unclassified Tachinids,	4,177
Named Tachinids,	1,600
Calosoma sycophanta, adults and larvæ,	978

thus making nearly 200,000 of the most active enemies of the gypsy moth and brown-tail moth liberated under the most favorable conditions during the year.

The results of the colonization work of previous years have not become very evident. It is altogether likely that the species introduced have found conditions favorable to their increase, and that at the present time they exist in considerable numbers. The area, however, is so extensive as to make their occurrence in ordinary collections a matter of chance rather than of likelihood. There have been during the past two years a tremendous destruction of the larvæ of both brown-tail moth and gypsy moth from bacterial and fungous diseases. These diseases have appeared in spots, but unfortunately some of these localities were those where colonies of parasites had been established, and in the wholesale destruction of the caterpillars by disease the introduced parasites must have suffered severely. Knowledge has been gained, however, which will make it more easy to select better localities for colonization in the future. Several of the parasites have been found to have established themselves, and notably the predatory beetle (*Calosoma sycophanta*) has been found in numbers. At least seven species have been found under conditions which indicate their establishment.

There have been imported, in all, 23 species of Hymenopterous parasites, of which 16 are European, 6 are from Japan and 1 at least is common to both regions. Eleven of these have been reared from the gypsy moth, 6 from the brown-tail moth and 6 from both insects.

A number of species of secondary parasites have been reared and have been killed.

Of Dipterous parasites, at least 29 distinct species have been imported, of which nearly all are parasitic upon both gypsy moth and brown-tail moth.

Of Coleoptera, 5 species have been imported, all of which will feed upon both gypsy moth and brown-tail moth.

This makes a total of 57 beneficial species, enemies of gypsy moth or brown-tail moth, or both, that have been brought over in the course of this work.

All visitors to the laboratory at Melrose Highlands have been impressed, not only with the large size of the undertaking, but with the extreme care with which all operations have been conducted. Scientific men have been practically interested in many of the extremely novel discoveries that have been made in the life histories of the parasites and in practical methods of breeding. The whole subject of the proper operations in order to secure the best results proves to be more complicated than any one had supposed before this large-scale experiment was undertaken, and discoveries are being made almost daily of absolute novelty in the field of biological science.

Co-operative assistance in the work of carrying on some biological investigations suggested by the practical work, and for which the material is present in great quantity at the laboratory, has been gained through the kindness of Profs. E. L. Mark and W. M. Wheeler of Harvard University. It has been considered most desirable that the workers at the laboratory, whether they are paid by the State or by the United States Department of Agriculture, should devote their time exclusively to the immediate practical end of the investigation; but what appears to be the purely scientific aspect must not be neglected, since its study will in the future, as it has constantly done in the past, indicate points of practical value to the progress of the rapid establishment of the parasitic species. The writer considers himself and the State of Massachusetts particularly fortunate in securing the co-operation of the men just mentioned.

On the date of the present writing the cheering news comes from Mr. Fiske, in charge of the parasite laboratory at Melrose Highlands, that the European *Pteromalus* has emerged in gratifying numbers from brown-tail moth nests collected in the vicinity of one of the last spring colonies. The outlook is now more favorable than at any period during the progress of the work. Success seems an ultimate certainty, but the time at which perfectly obvious results will be apparent is as yet uncertain. By perfectly obvious results I mean a marked diminution in the numbers of gypsy moth and brown-tail moth over a region of some extent, which by expert examination can be shown to have been brought about through the work of introduced parasites.

SUMMARY OF RECOMMENDATIONS.

Recommendations are: —

1. To continue the field work at its maximum efficiency, an appropriation of $150,000, in addition to that already provided for the year 1909, should be made.

2. To continue the work of importation of parasites and for work on fungous and bacterial diseases, an appropriation of $15,000, in addition to any unexpended balance, should be made.

3. To provide for the uninterrupted continuation of the work against the gypsy and brown-tail moths, that the work may not suffer from legislative delays in the winter and spring, when most effective work can be done, a suitable appropriation should be made for a period of at least three years.